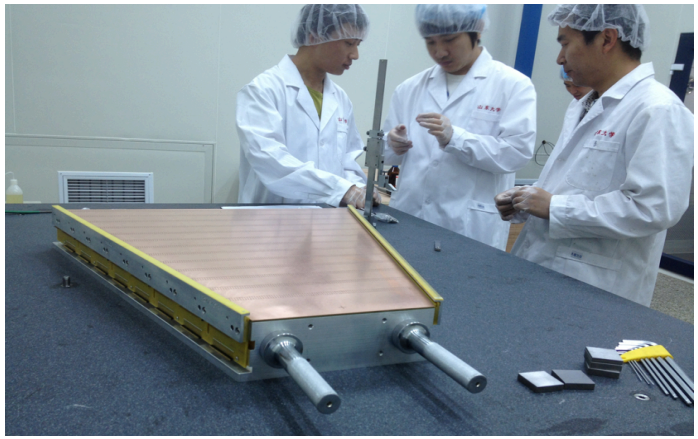
MWPC production plan and resources

Qinghua Xu(Shandong University)

iTPC review, Sep. 13, 2016



Thanks to my colleagues:
Changyu Li, Jian Deng, Peng Lu, Yansheng Sun, Chengguang Zhu,
Xu Wang, Fuwang Shen, Shuai Wang, Chi Yang (USTC)
+ many other iTPC colleagues

Outline:

- Scope of effort with project
- Funding and man-power
- Facilities & laboratory
- Prototype work done
- Time scale of production plan
- Risks and mitigation

Scope of effort with project

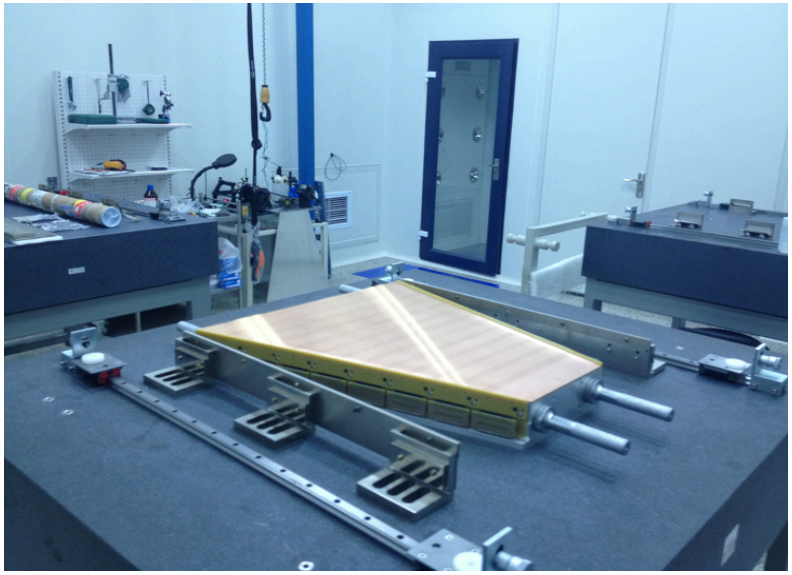
- Prototype of iTPC sector
- 28 wire plane production
- Assembly of 24+3 sector (after pcb bonding at LBL)
- Sector test (uniformity, efficiency, linearity)
- Ship the 24+3 sectors to BNL

Funding & manpower in China for iTPC

- 6.5M RMB (~1M $) support in total from China for MWPC :
  - ✓ 2M RMB from MoST 973 key project for high energy nuclear physics (2014-2018)
  - ✓ 3M RMB from NSFC key project for international cooperation (2016~2020), approved Sep. 2015.
  - ✓ 1.5 M RMB in-kind contribution from Shandong University.
- Manpower & institutions:
  - ✓ SDU: 2 faculties+ 1.5 engineers + 3 students+1(3) technician - assembly, testing
  - ✓ USTC: 1 professor+1 postdoc - testing
  - ✓ SINAP: 1 professor+1 postdoc - calibration

MWPC- iTPC laboratory at SDU

- New building in 2000 for ATLAS Thin Gap Chamber (TGC). Produced 400 modules of high quality TGC for ATLAS during 1999-2004.
- The lab is ~400m^2 , recently refurbished. New clean room built for iTPC project.
- Cosmic ray test system available for detector test.



Clean room with granite table

Cosmic ray test system

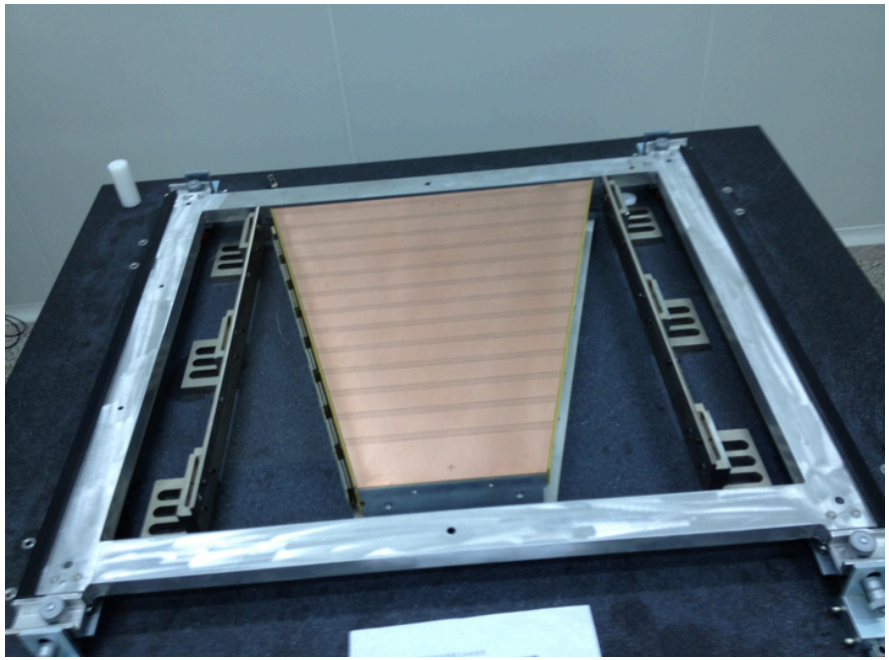
Wire winding for MWPC at SDU

- **Three layers of wire for iTPC MWPC:**

  -Wire pitch and tension controlled by winding machine, originally from Israel. New machine, upgraded from previous.

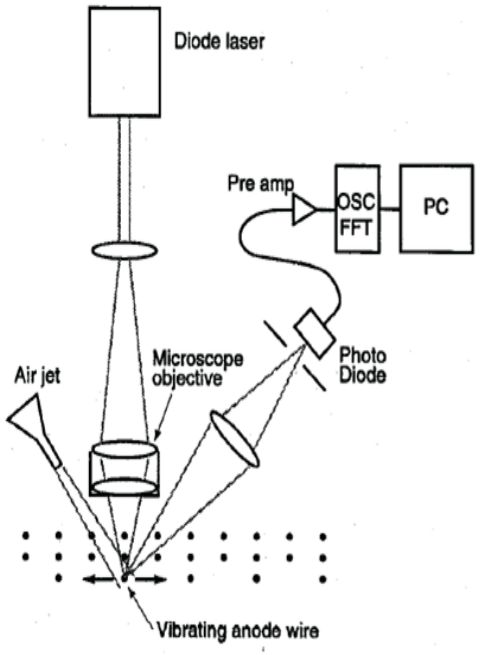
Wire	Diam. (μm)	Pitch (mm)	Composition	Tension (N)
Anodes	20	4	Au-plated W	0.50
Anodes—last wire	125	4	Au-plated Be–Cu	0.50
Ground plane	75	1	Au-plated Be–Cu	1.20
Gating grid	75	1	Au-plated Be–Cu	1.20

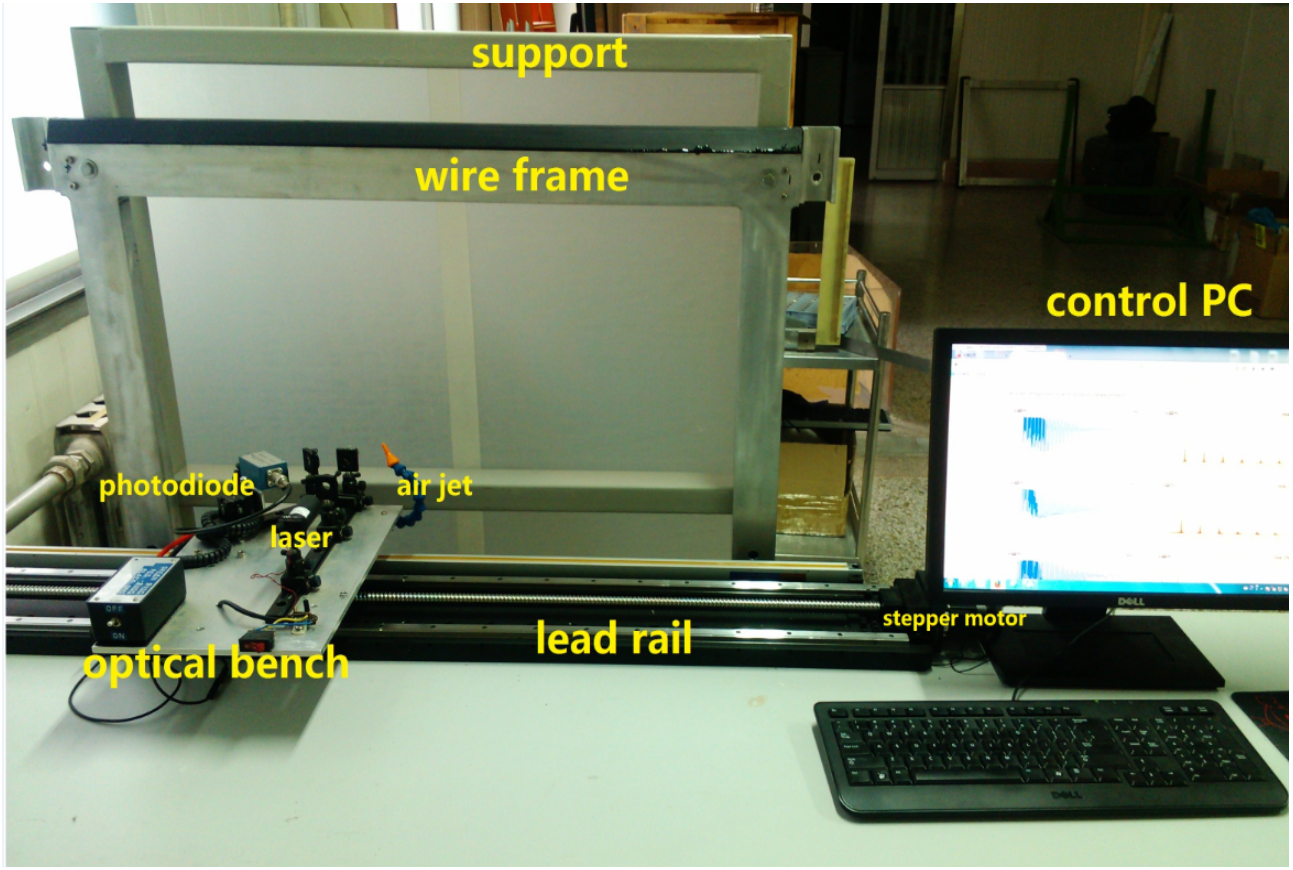
Wires first wound on frames, and then will be used for 3 layers of wire plane with wire combs, to keep height and pitch precisely (~10um).



Wire tension measurement system

- Determine wire tension by optically measuring the vibration frequency:

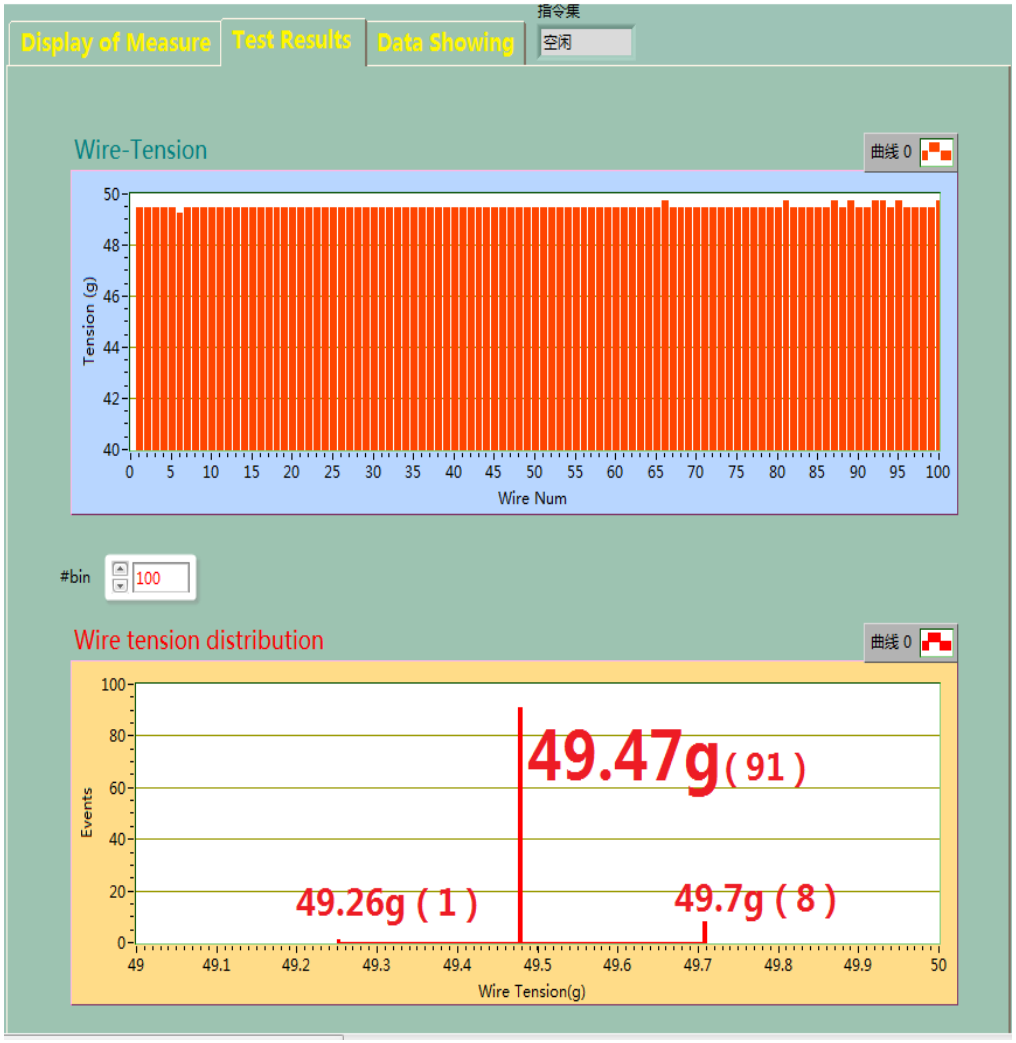


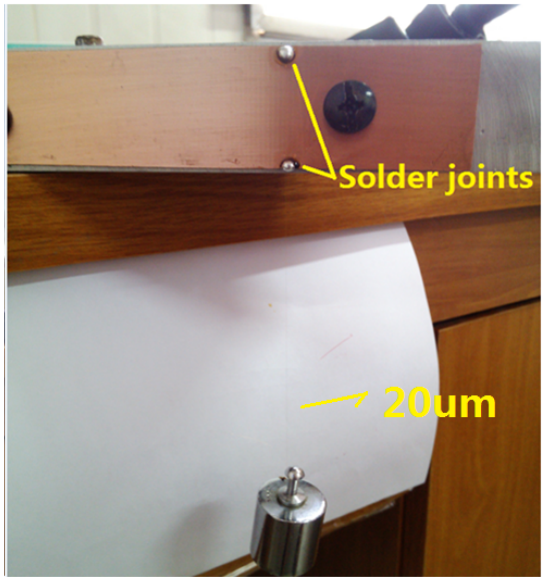


Laser scan each wire，synchronized with gas jet, and the base frequency will be extracted from voltage fluctuation transformed of laser absorption.

Wire tension measurement system

- **Cross-check of the method with fixed tension wires:**





Fixed tension for checks

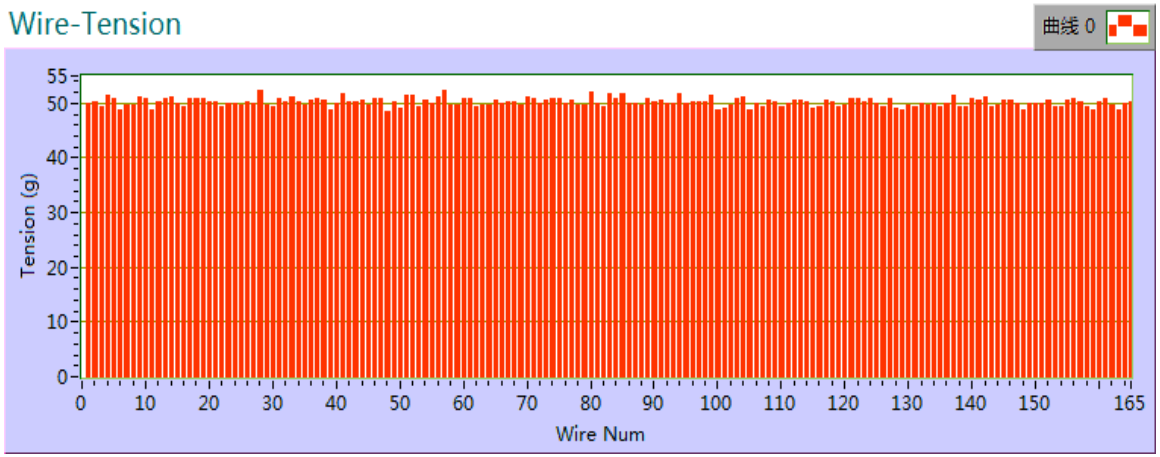
Measurement with fixed tension: (<2%)

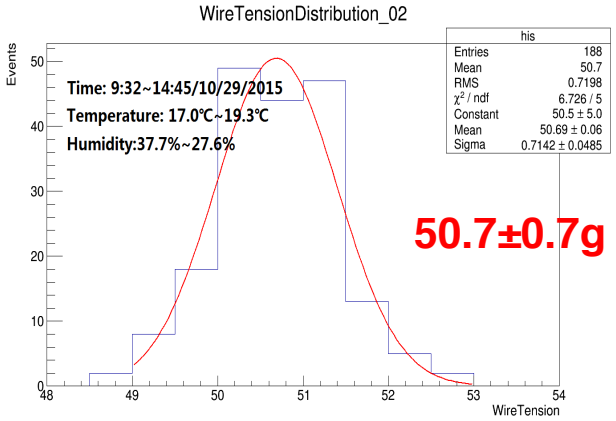
Wires	1	2	3
50g	49.5g	50.8	50.6
60g	60.9	60.6	60.4

Wire tension measurement –Test frame #1 （20um)

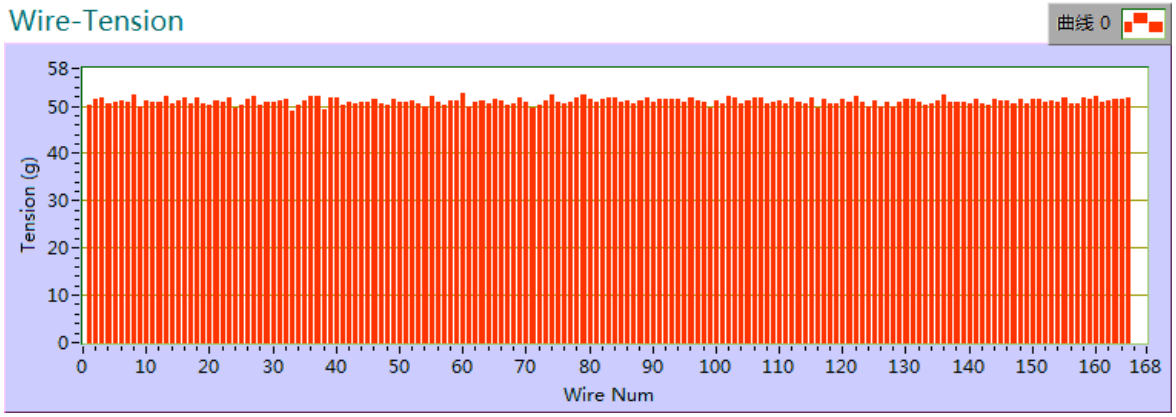
- **Measured tension of 165 wires on wire frame:**

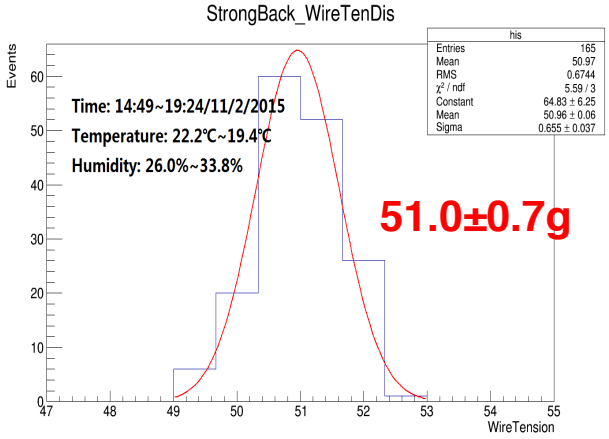
Required to be 0.5±0.05N (51±5gram)





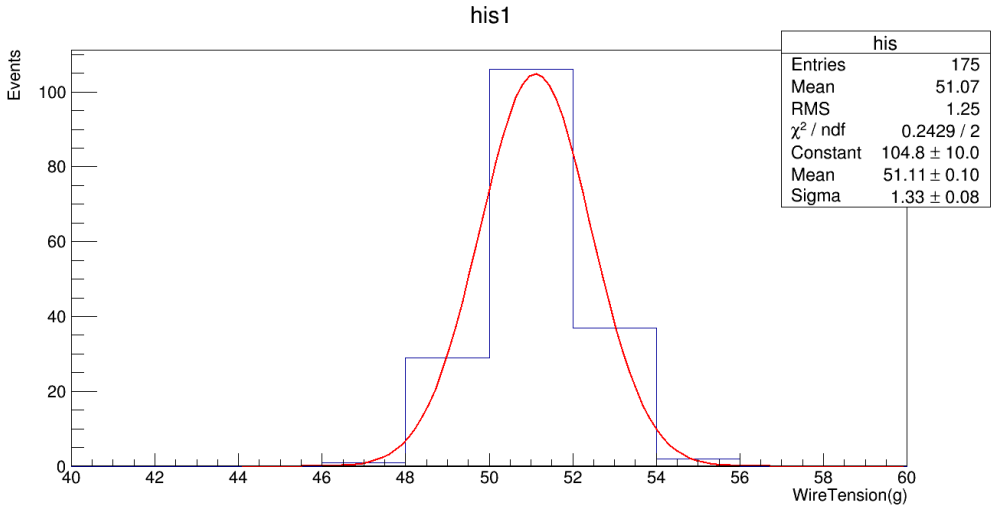
- **Measured tension of 165 wires after glued on anode wire mounts:**





Wire tension measurement –Test frame #2（20um)

- **Measured tension of 175 wires on wire frame:**



Required to be 0.5±0.05N (51±5gram)

51.1±1.3g

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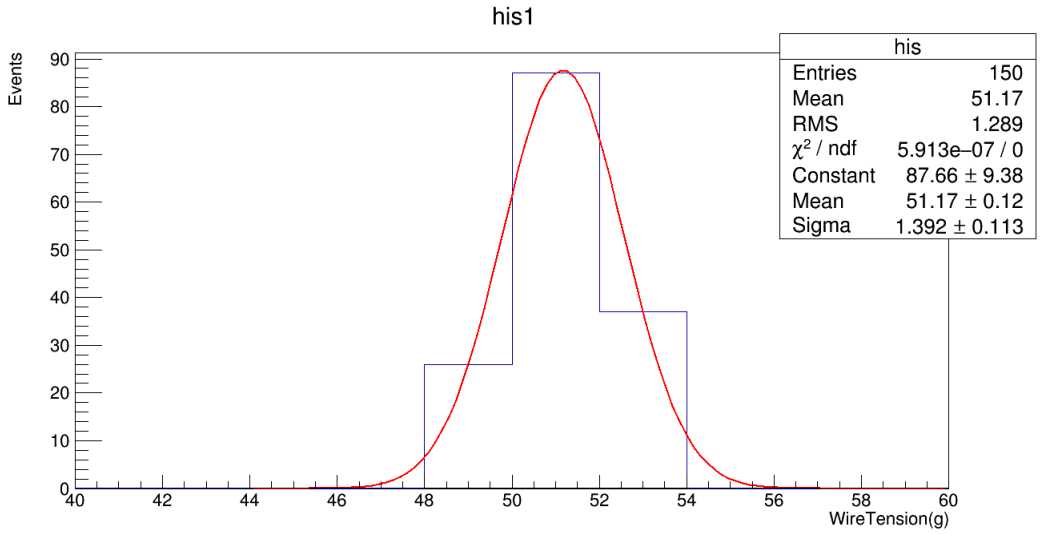
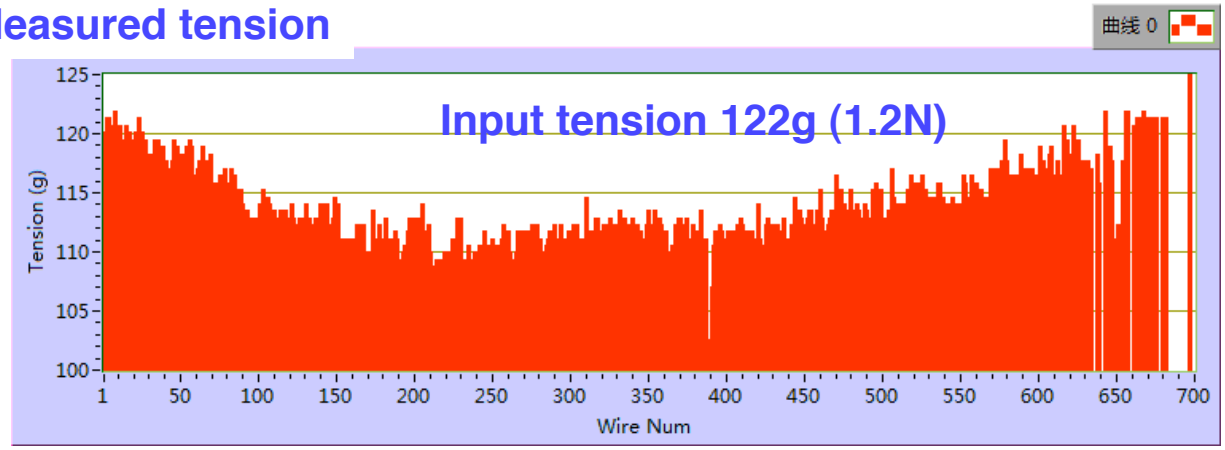


51.2±1.3g

Wire tension distribution for 1.2N BeCu Wire frame

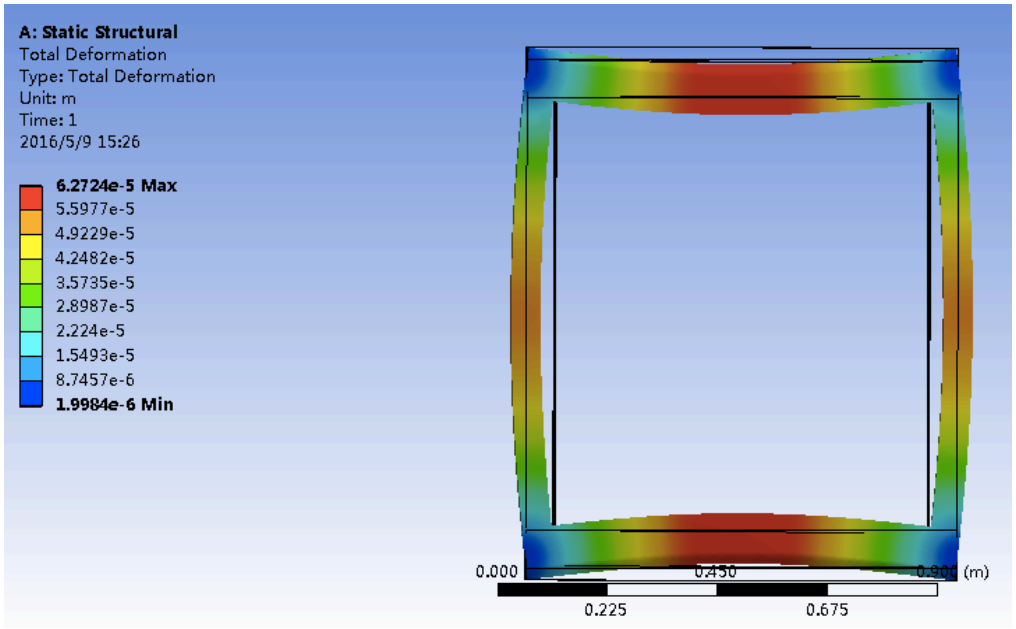
- **Tension drop due to deformation of wire frame (similar as original one):**

Measured tension



Total load ~80Kg

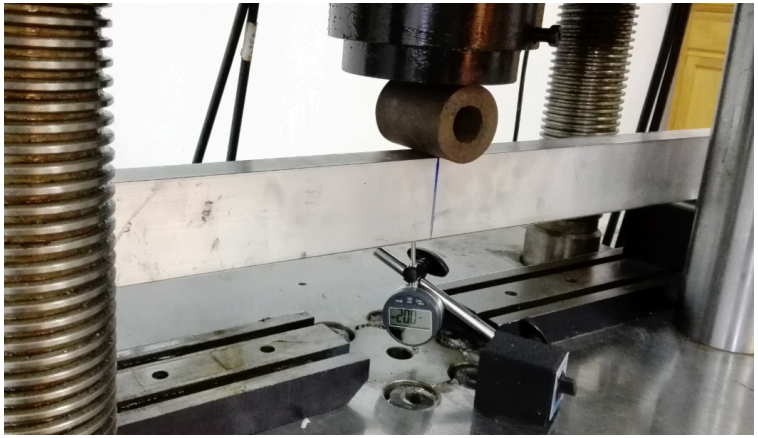
- **ANSYS simulation**

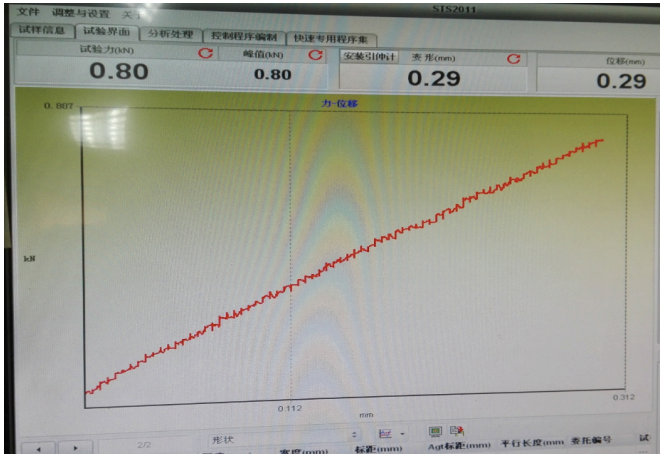


Consistent with distortion measurement ~60um

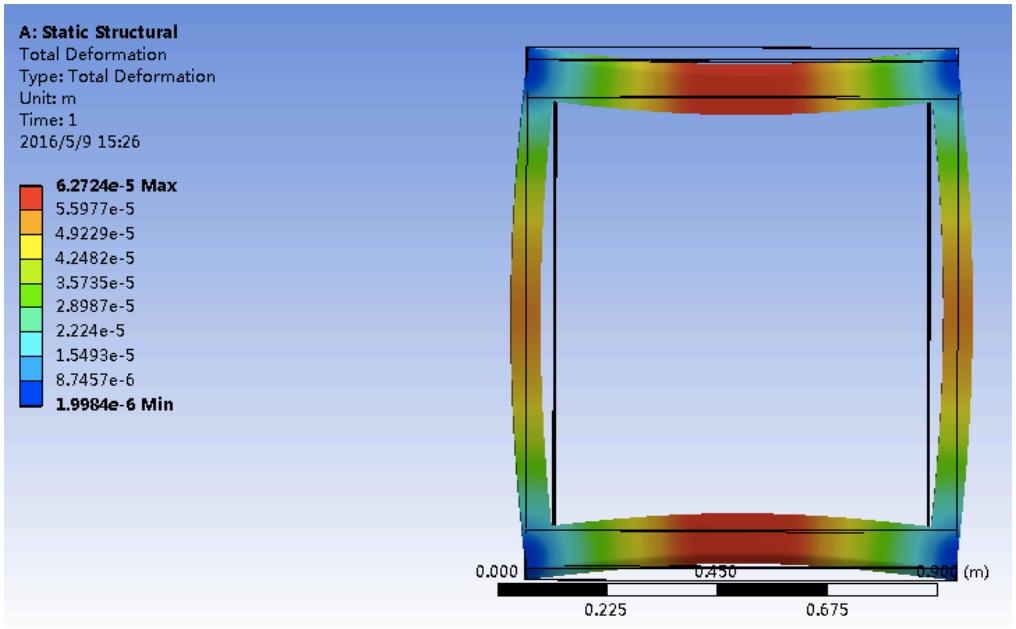
Wire tension distribution for 1.2N BeCu Wire frame

- **Measurement of distortion:**





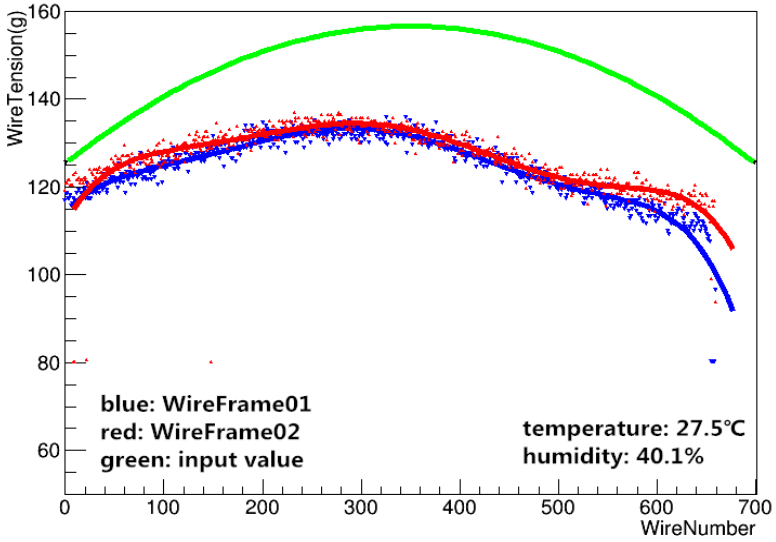
- **ANSYS simulation**



Consistent with distortion measurement ~60um

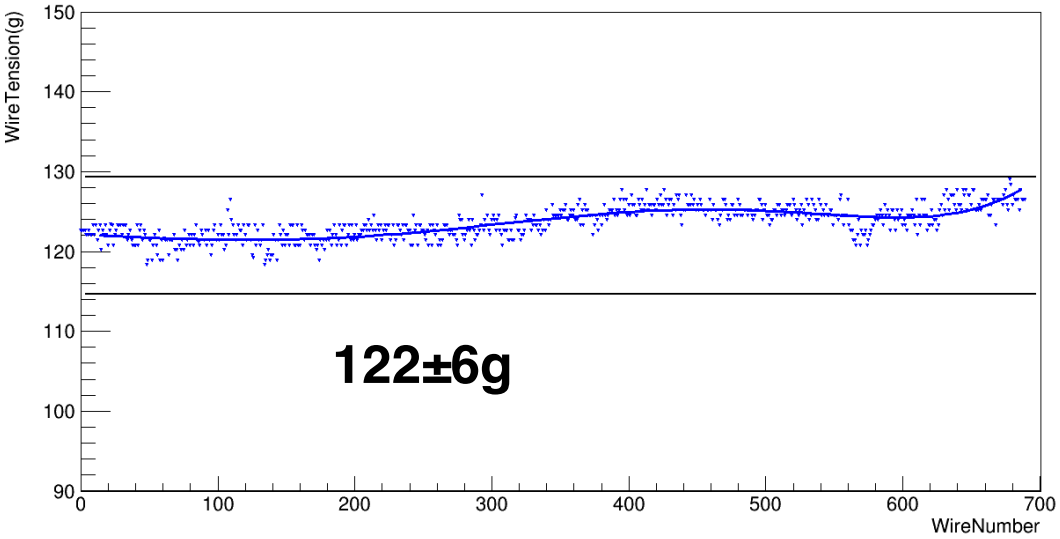
Wire tension distribution for 1.2N BeCu Wire frame

- Programing on the tension for each wire while wire winding after including the distortion effect for BeCu wire plane
  -an example



First Measurement

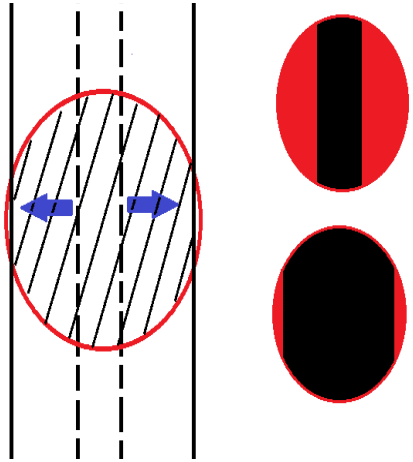
- Obtained the desired tension by tuning the input curve on tension:

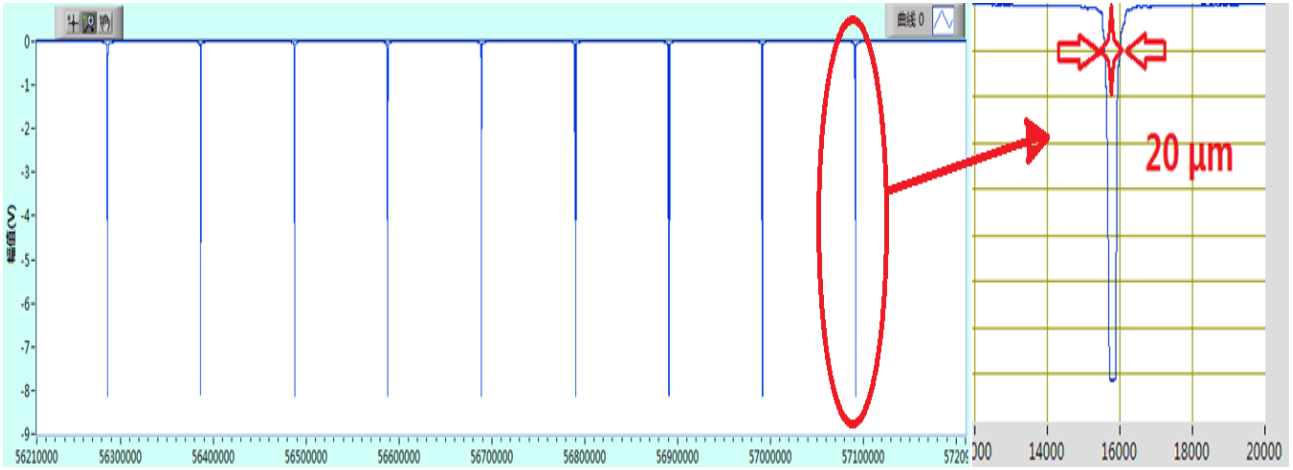


-122±6g is consistent with traveller and STAR TPC in 1990's

Measure the pitch of wires using the same laser system

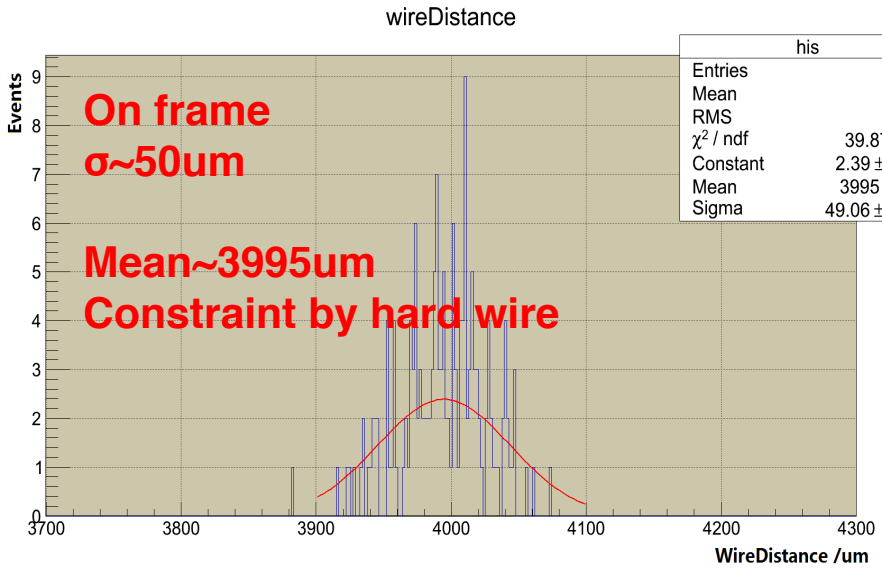
- **Focusing the laser on each wire, width of response is the wire diameter**

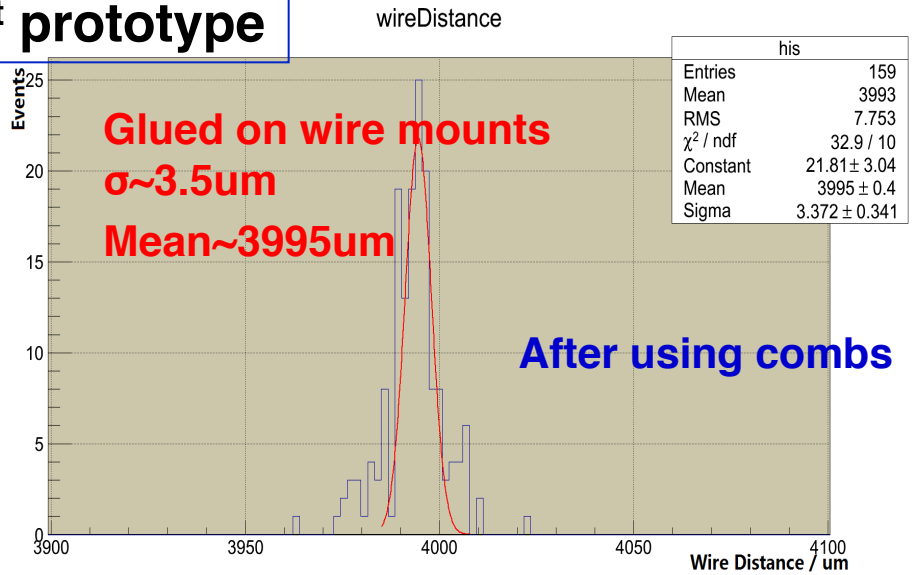




- **Distance between wires :**

1st prototype





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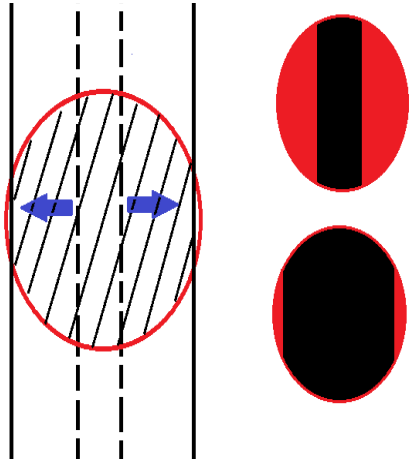
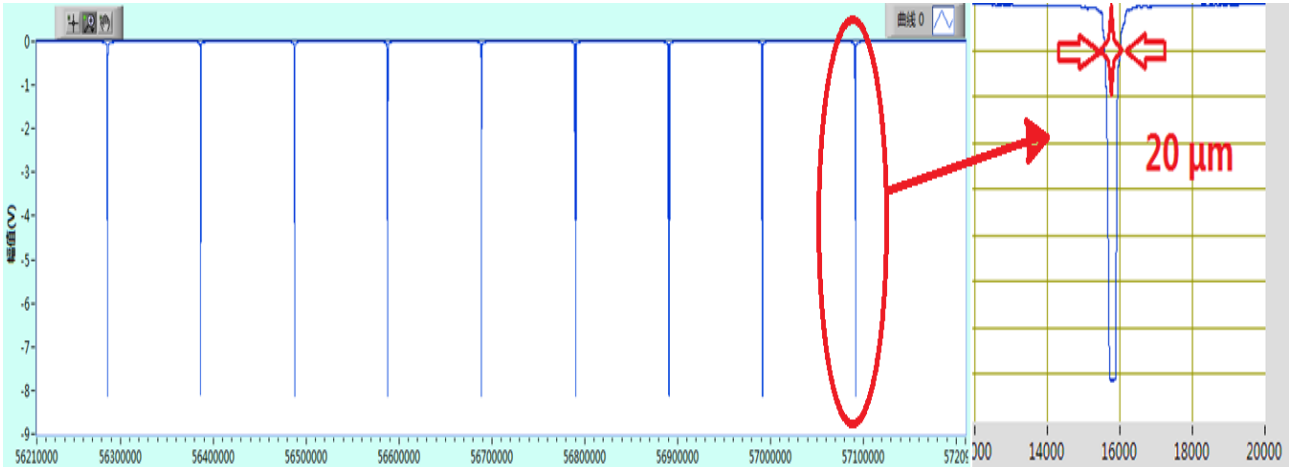
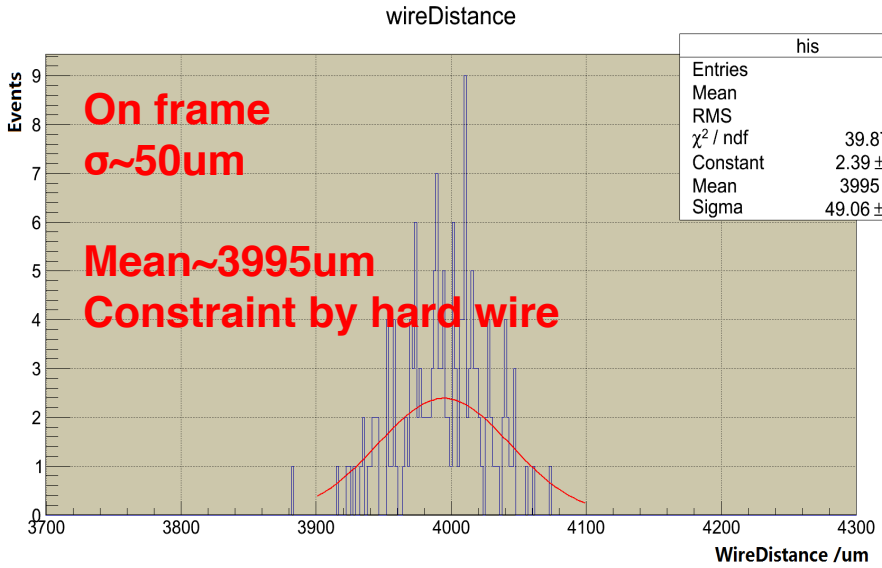
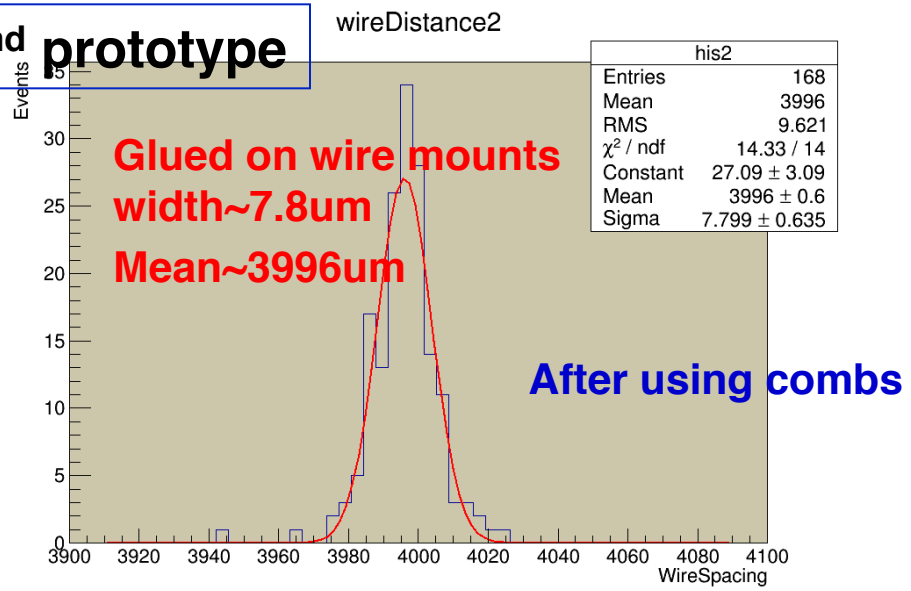




- **Distance between wires :**

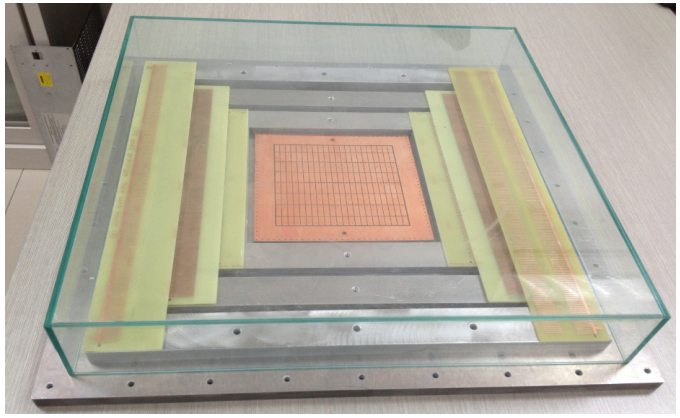
2nd prototype



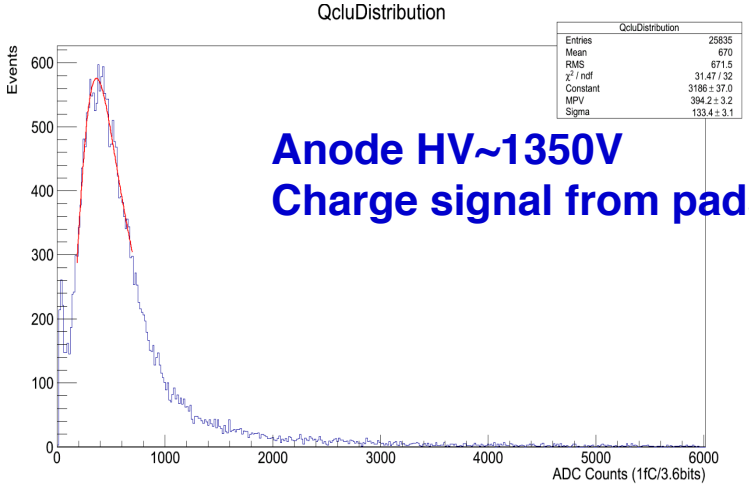


Began with small MWPC prototype

- **Small MWPC prototype made at SDU July 2014; Tested with cosmic ray system:**



Small TPC prototype

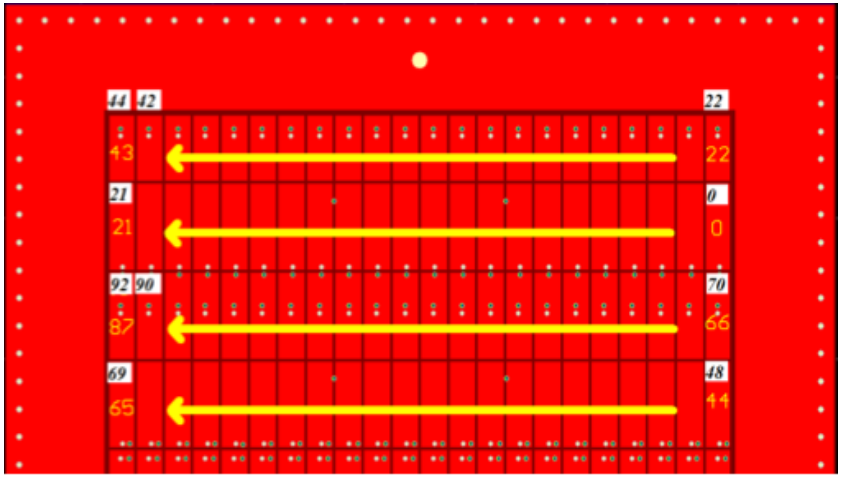


Anode HV~1350V
Charge signal from pads

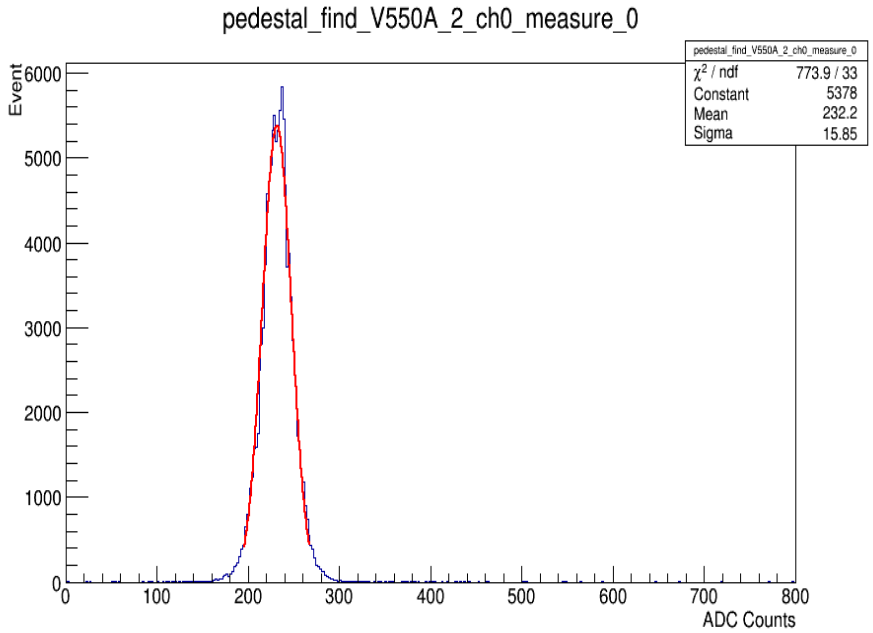
Cosmic ray test system

Test results of small MWPC

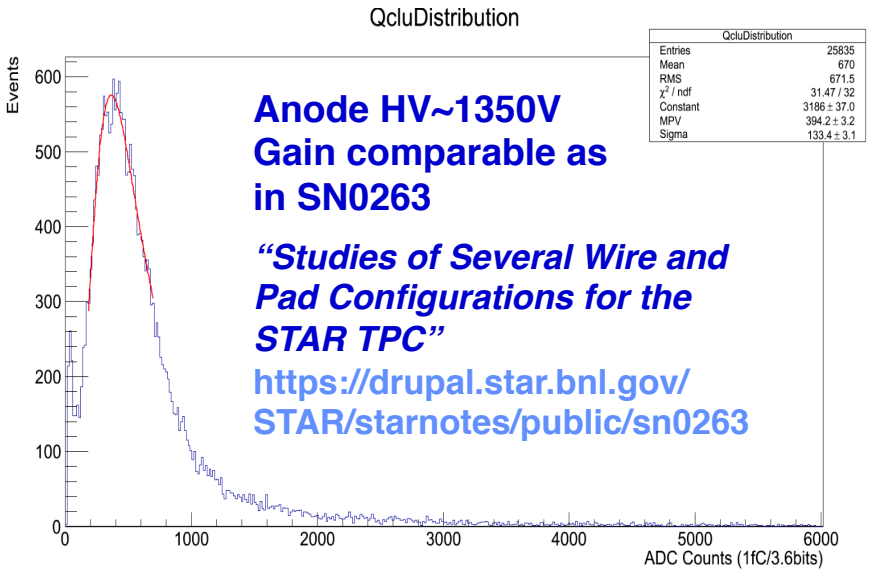
- Read out the charge of 88 pads of 176 in total with simple electronics (one V550A board).



- Pedestal seen for the charge of single pad



- Signal after subtracting pedestal



Anode HV~1350V
Gain comparable as in SN0263

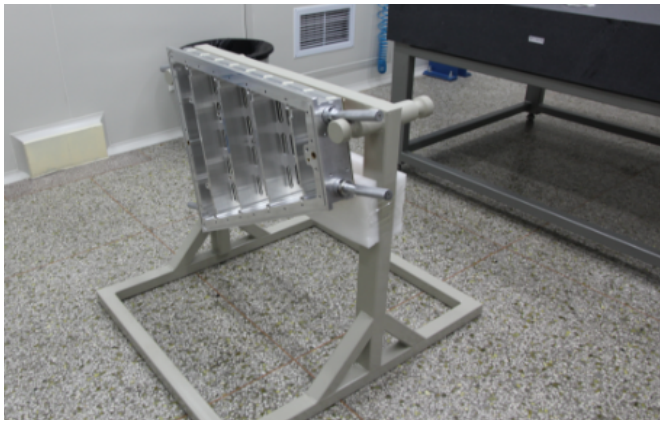
"Studies of Several Wire and Pad Configurations for the STAR TPC"

https://drupal.star.bnl.gov/STAR/starnotes/public/sn0263

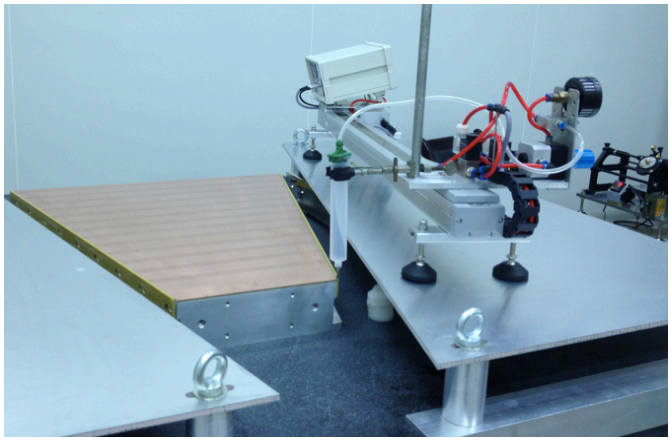
Tools & fixture for full size prototyping

- **Started the full size iTPC prototyping since September 2014. Several tools haven been made since then.**

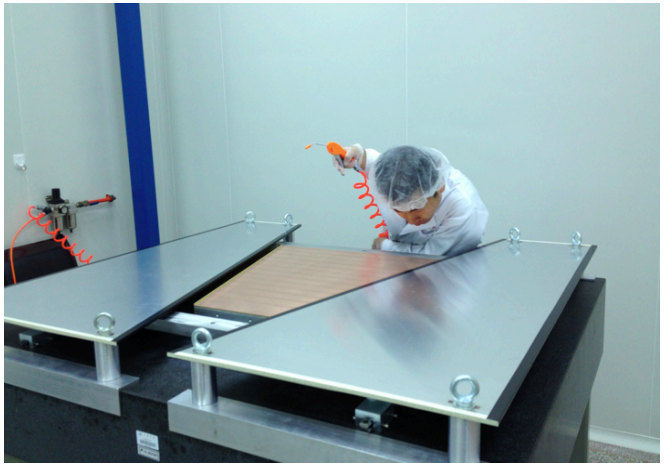
Drill/pin fixture



Gluing stand (anode WM)

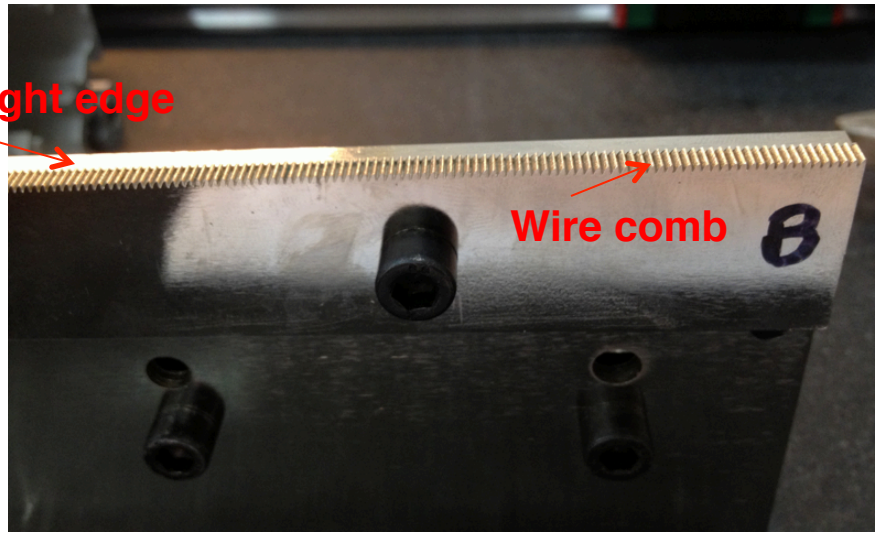


Gluing machine



Protecting cover

Wire combs to keep wire pitch and height

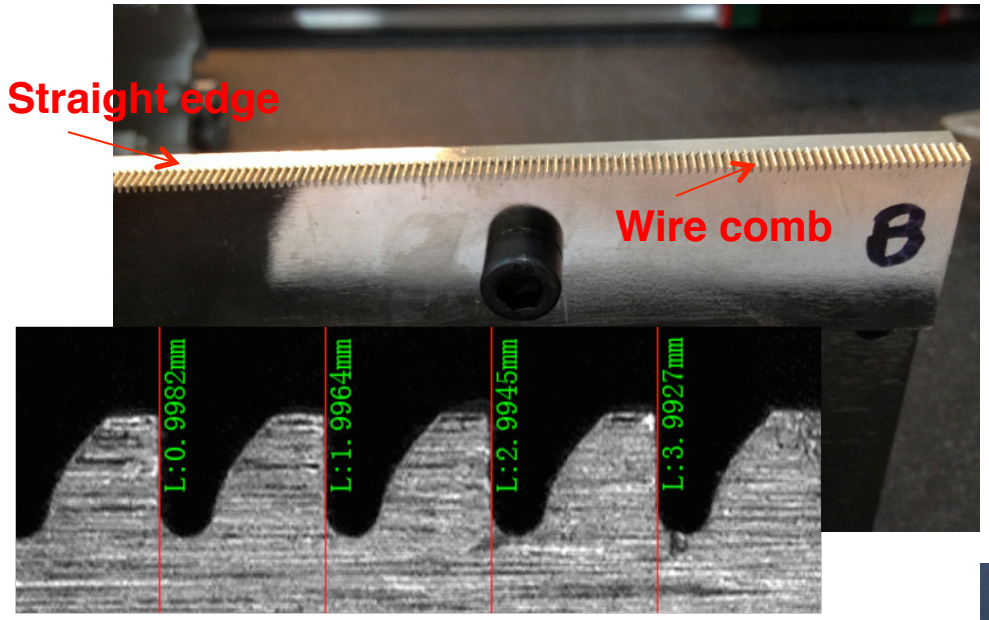


- Wire pitch and height is controlled by wire comb as originally used in STAR TPC.
- The flatness of straight edge should be <10um.
- The combs produced by LBL will be used.

- Mounting wire combs using height standard (tolerance <10um) and micromete(1um).
- Lowering down the frame to let the wire just touch the comb straightedge using micrometer head.

Height standard (σ<10um) (from granite table):
Pad plane : 86.550mm
Anode Wire: 88.540mm
Shield Wire: 90.513mm
Gated wire: 96.513mm

Wire combs to keep wire pitch and height



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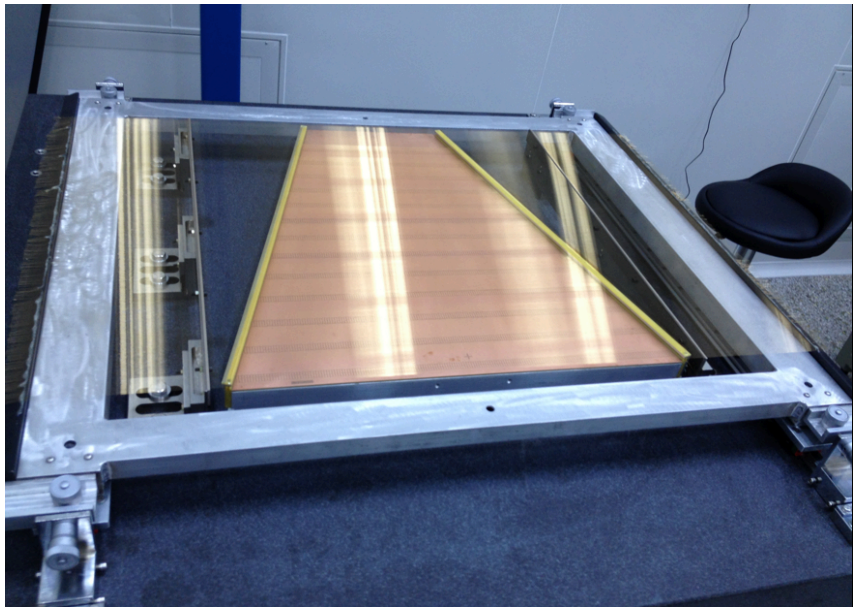
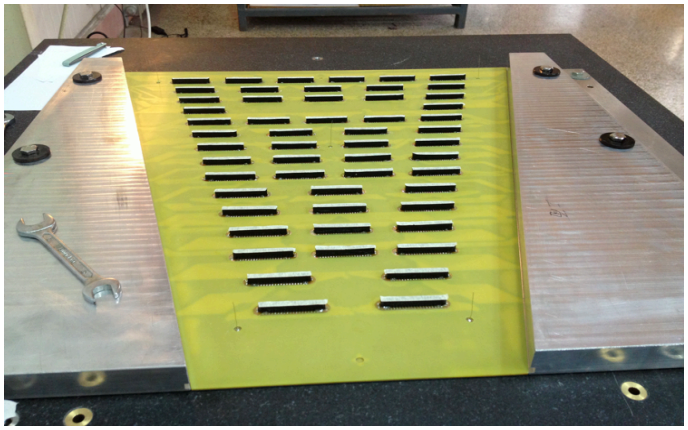
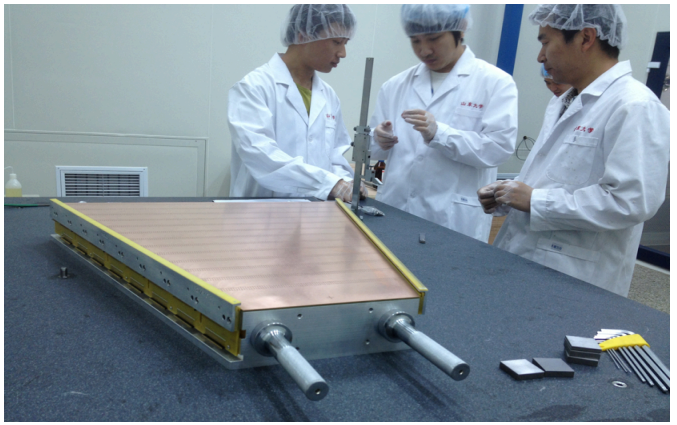


Full size iTPC prototyping

- Gluing pad plane to strongback, install 3 side wire mounts:

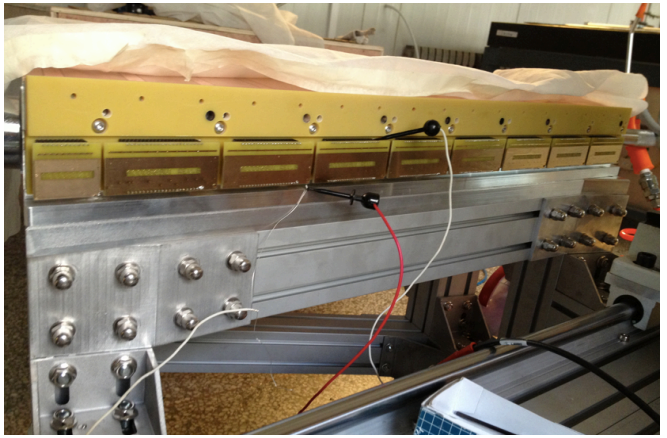


PCB bonding



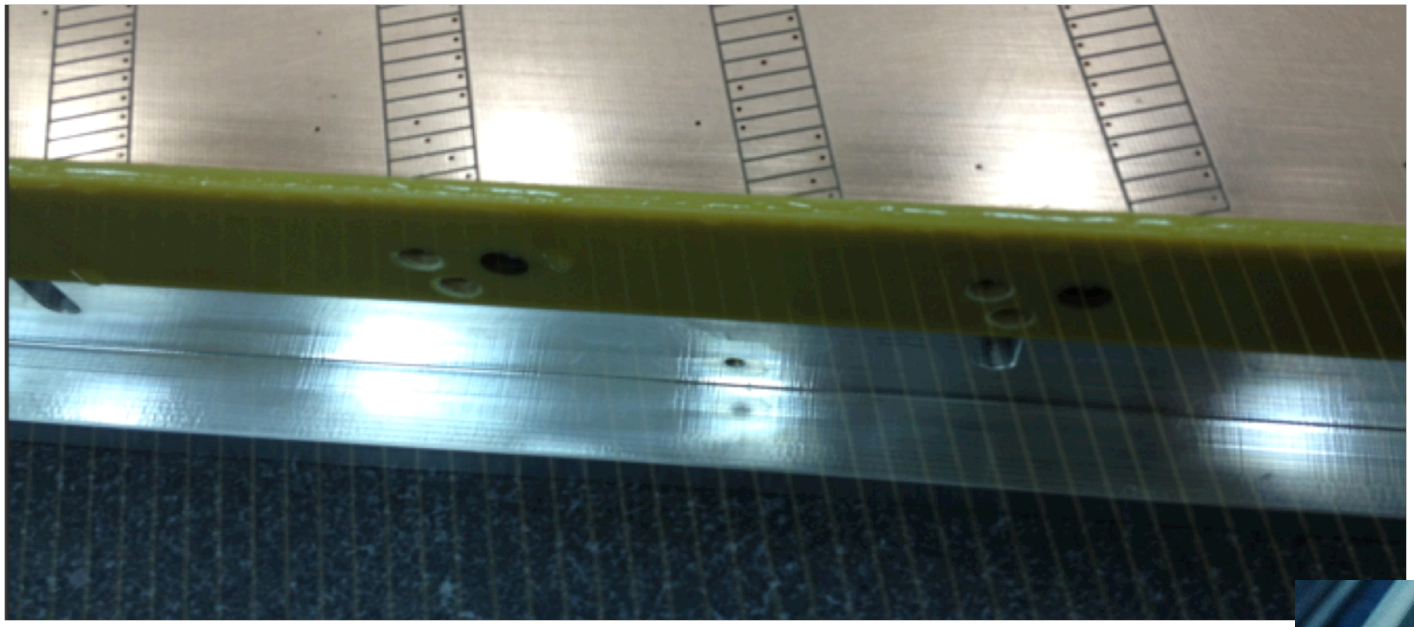
Side wire mounts

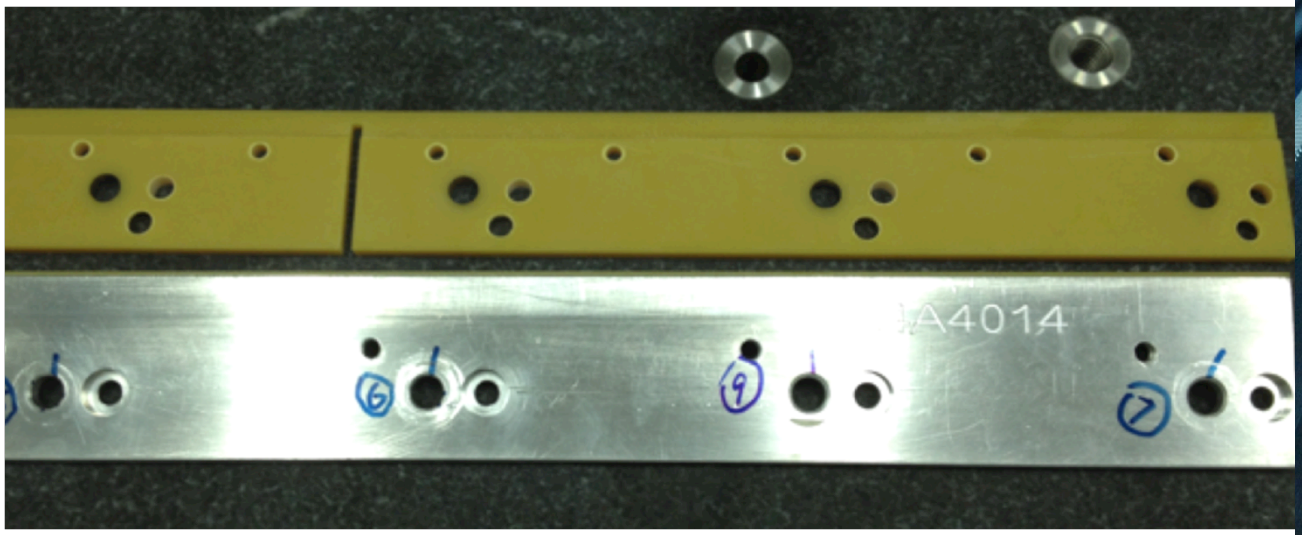
Pining the wire mounts

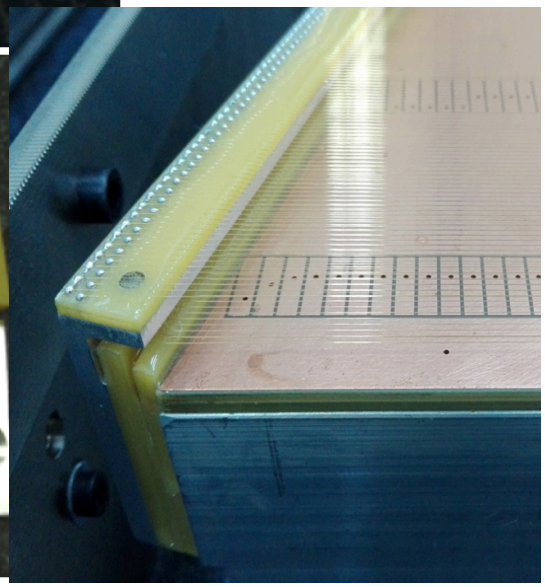


Leakage current, continuity, open test

Side wire mounts to hold the wire plane



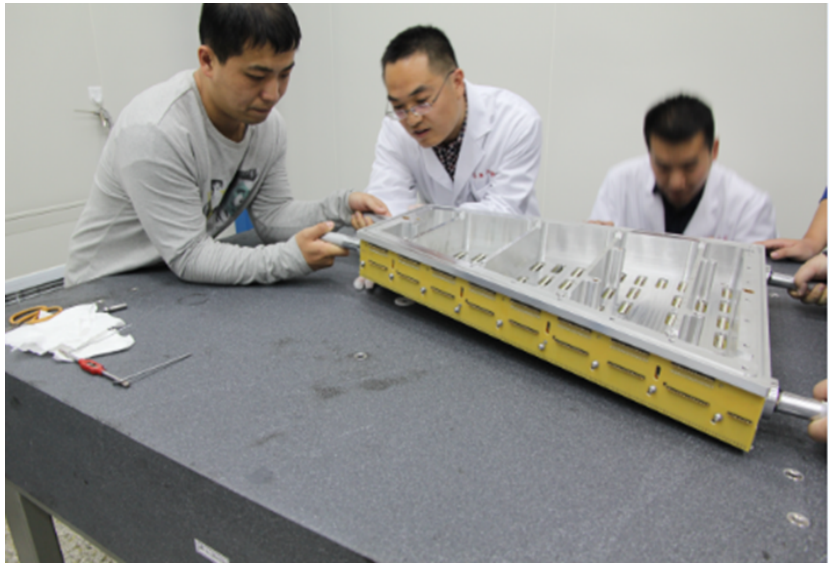




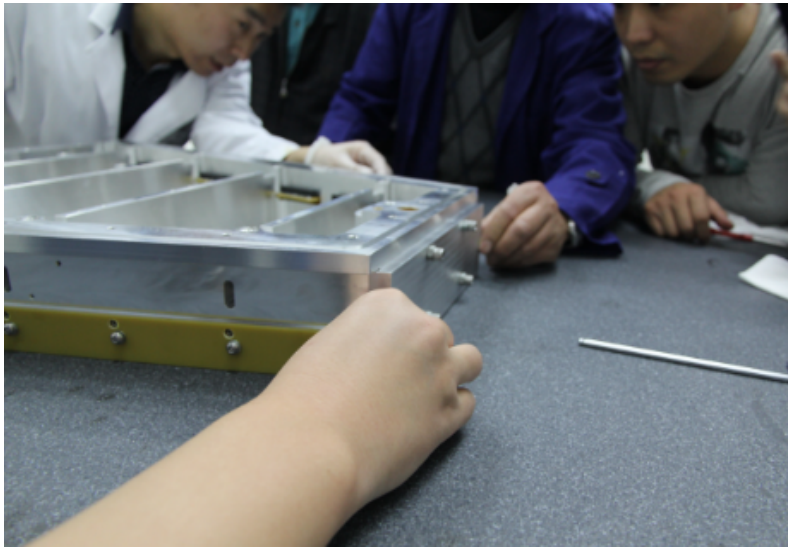
-Anode wire mounts glued, Shield & gated wire mounts installed with pin and screws

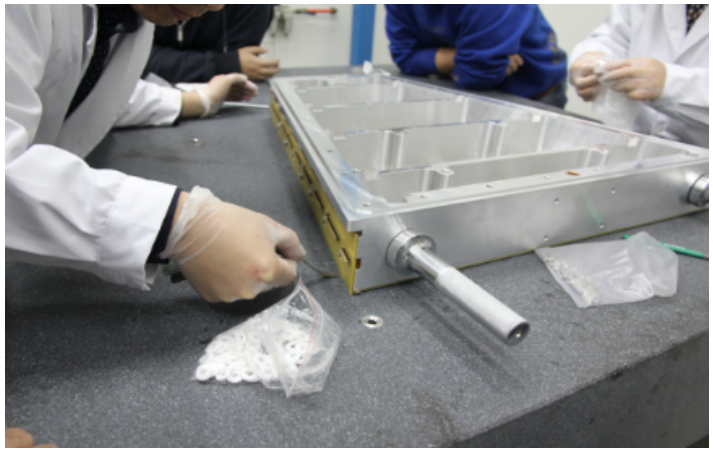
Install side wire mounts

Put the strongback on granite table over 4x1.85mm (3.85, 9.85) spacers, pad plane facing down.



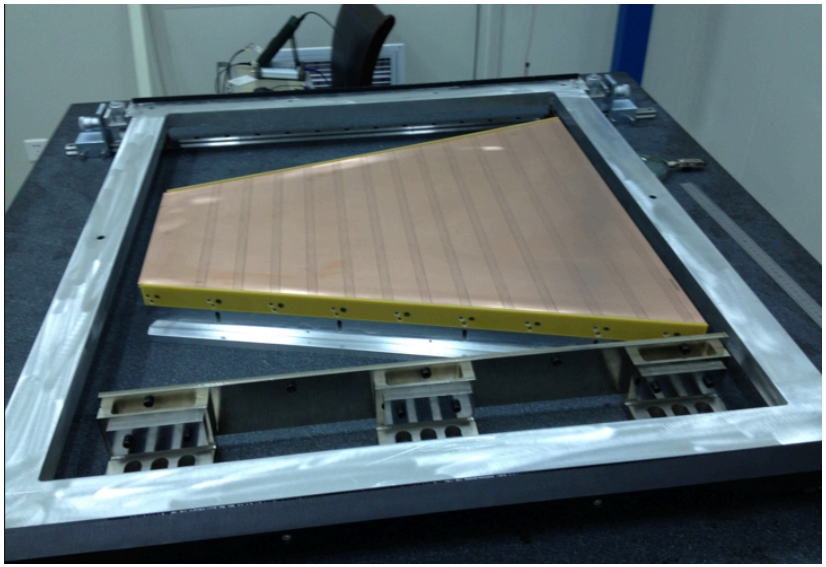
Push the wire mount against the mount stop, and resting flat on the granite table, while tightening the screws





Use 0.05mm strip to check the space between table and mounts,<50um.

Mounting the anode wires

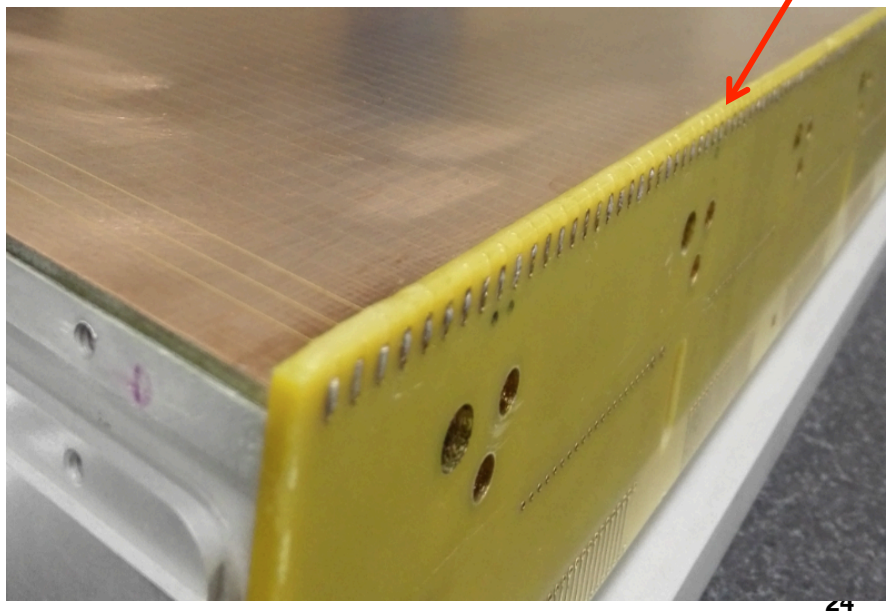


164 20um W wire
6 “fat” wire to lower the gain on the edge

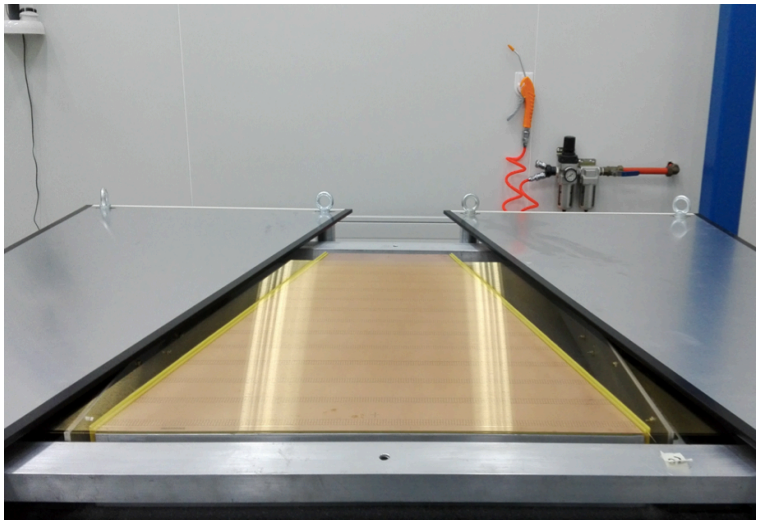
Epon 826 /Versamid 140 (3/2)
40 h to cure

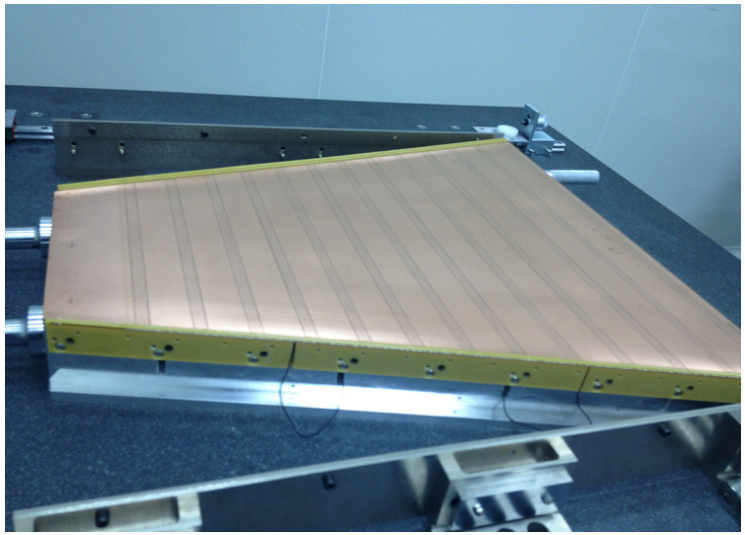
Modern recipe:
Araldite 2011-/AB (5/4)
24h to cure

Epoxy glued

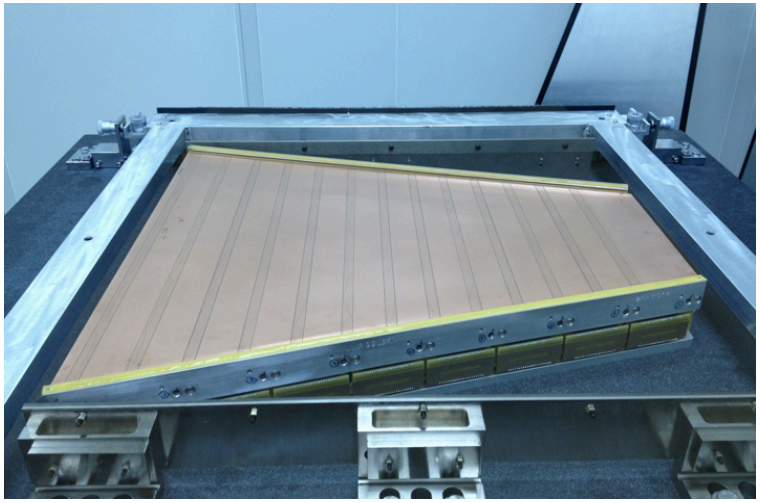


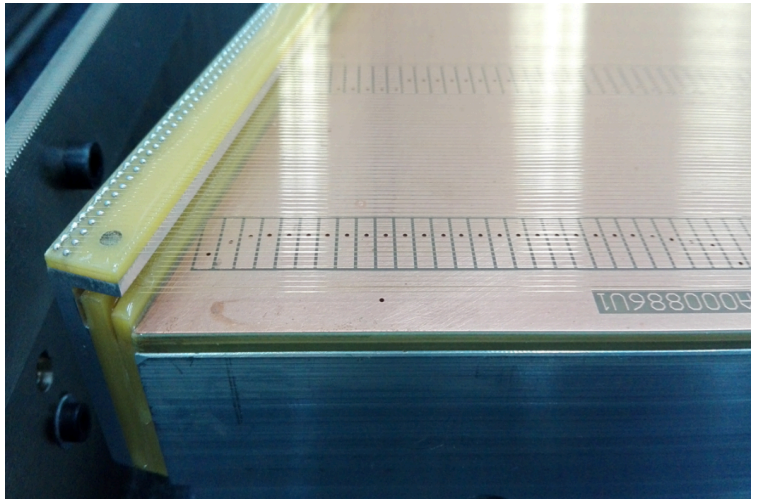
Mounting the shield & gated wires





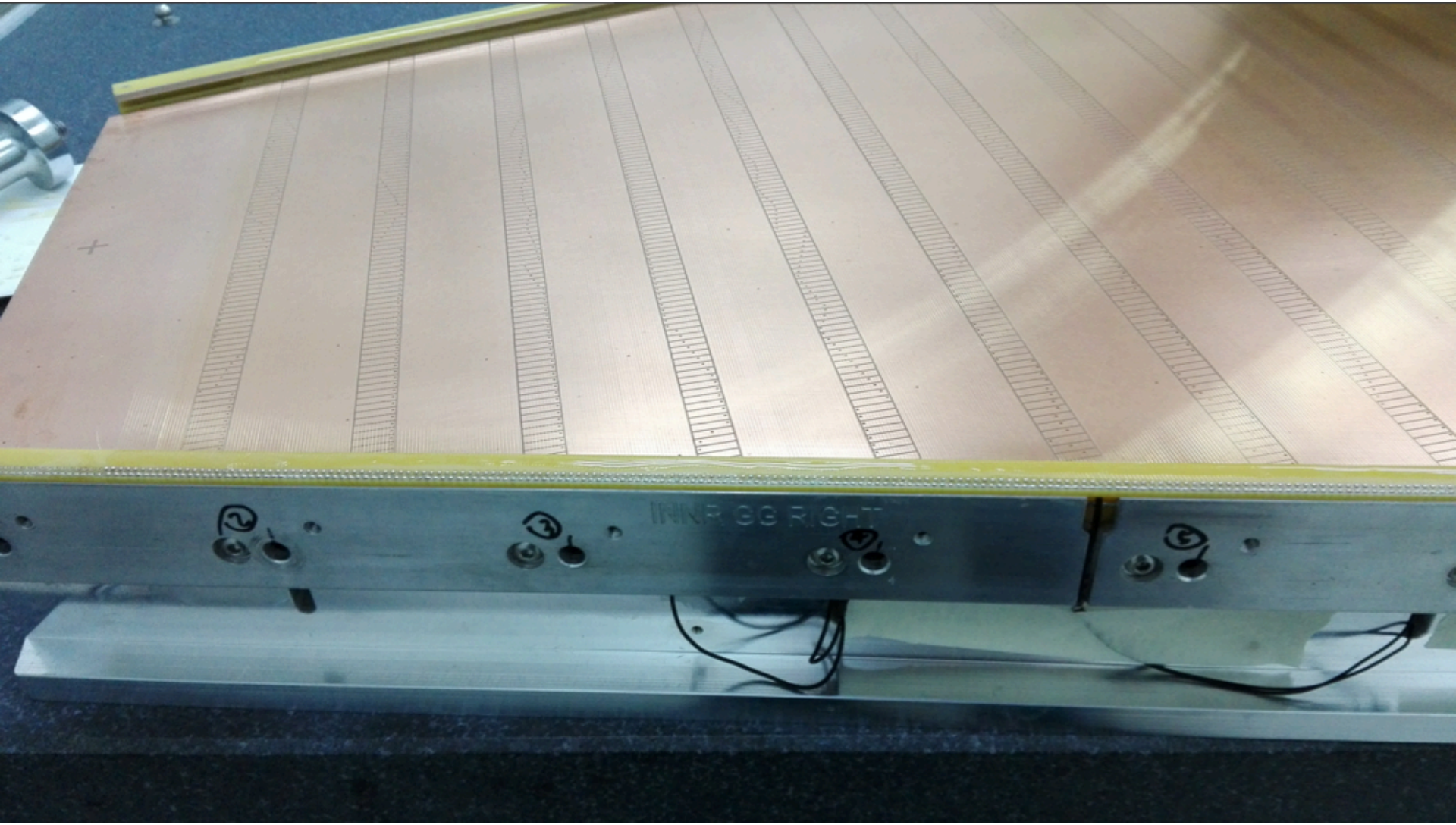
Shield wire plane epoxied and soldered



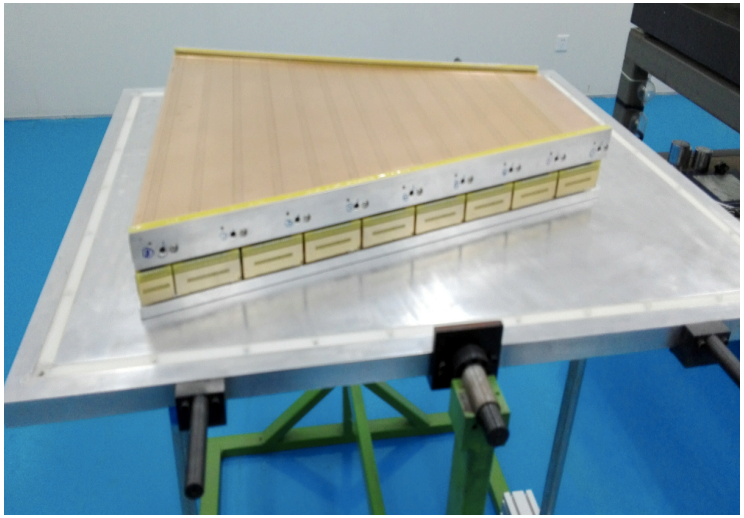


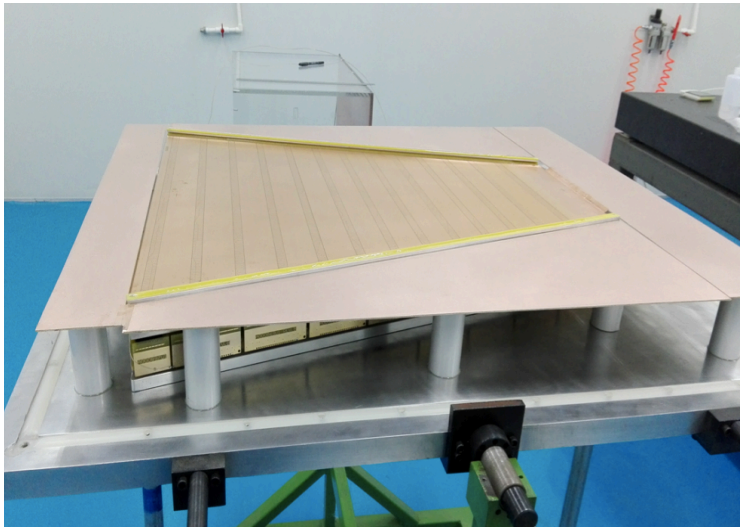
Gated wire plane epoxied and soldered

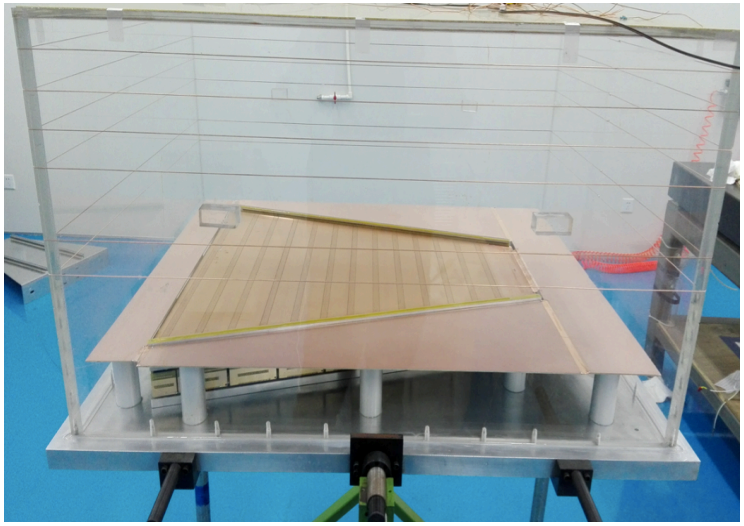
Gated wire soldered (681 solder points)

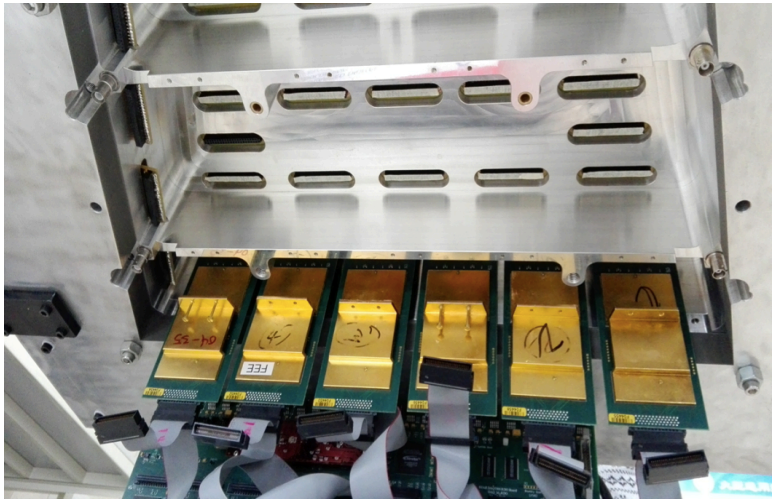


Sector in a Chamber



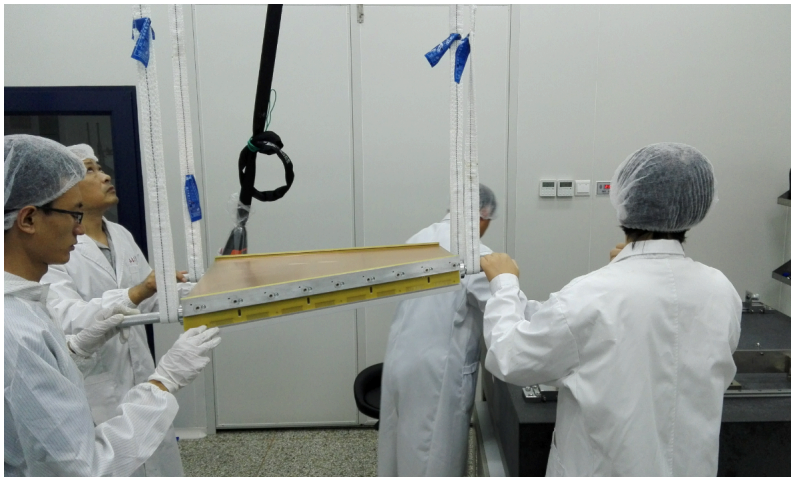


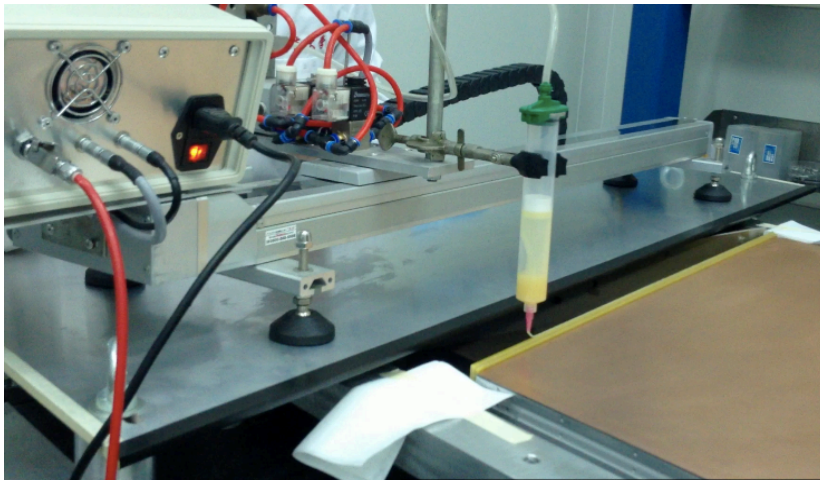


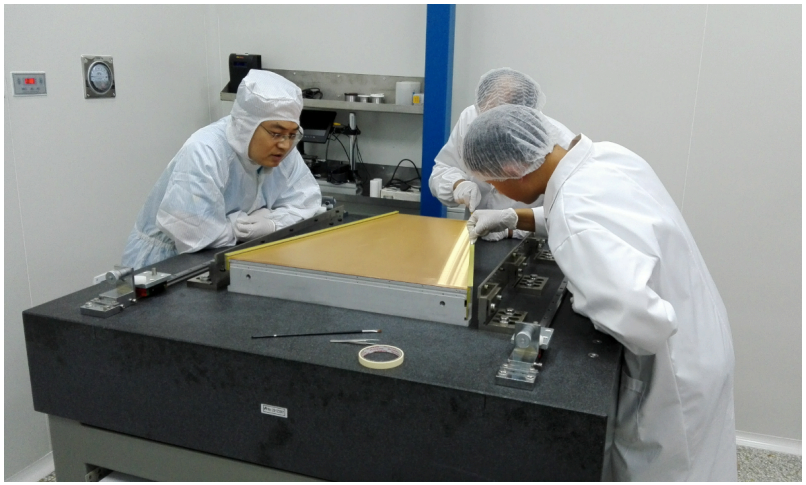


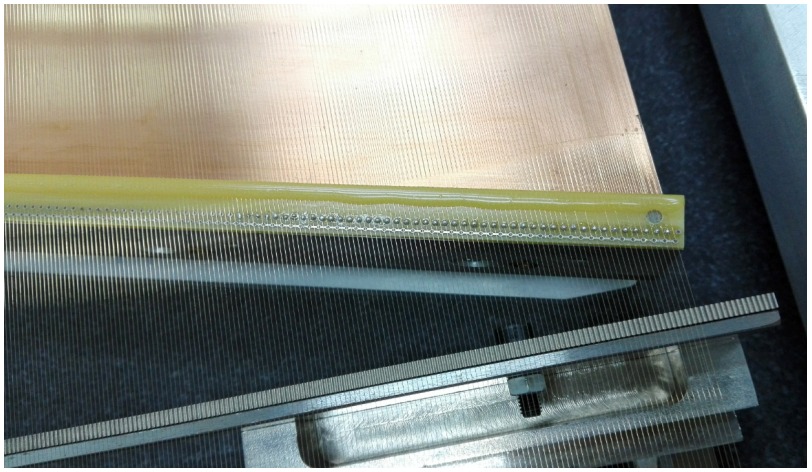
Sector in the chamber

Practicing MWPC & assembly this summer



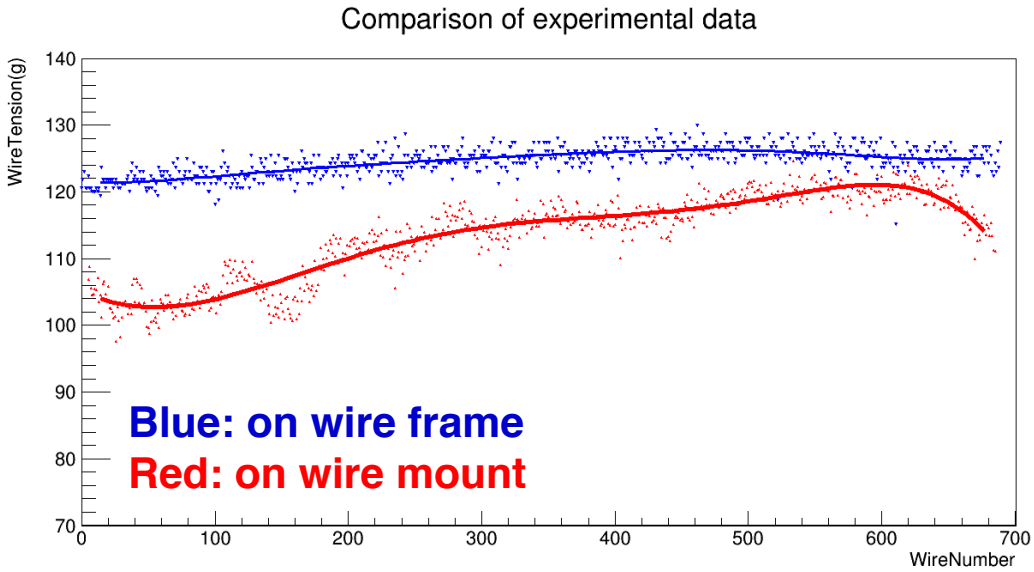






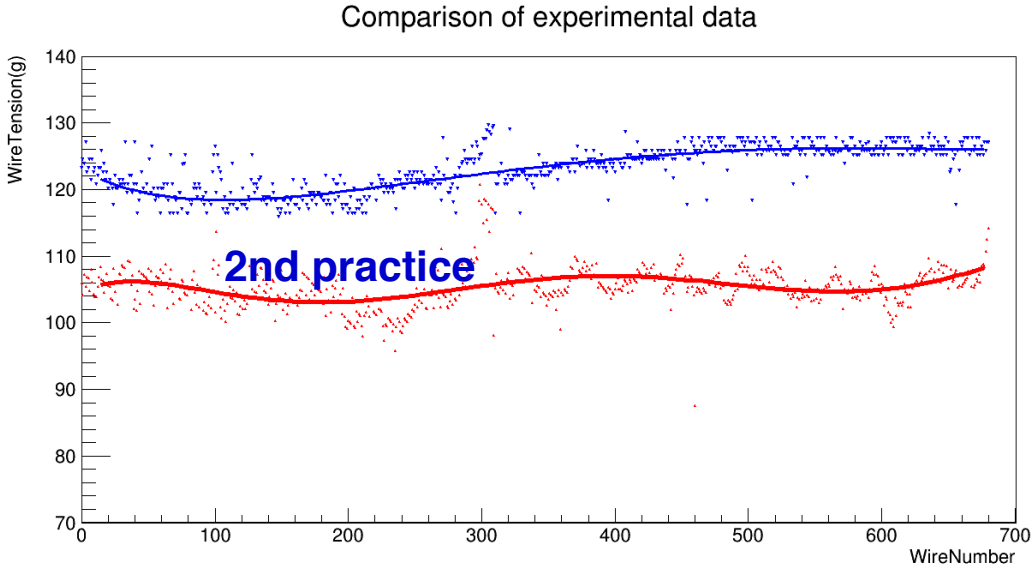
-Practiced twice the whole procedure of mounting 3 layers of wire using plane pcb, strongback, side wire mounts produced in China (not official)

Shield wire tension before & after mounted on sector



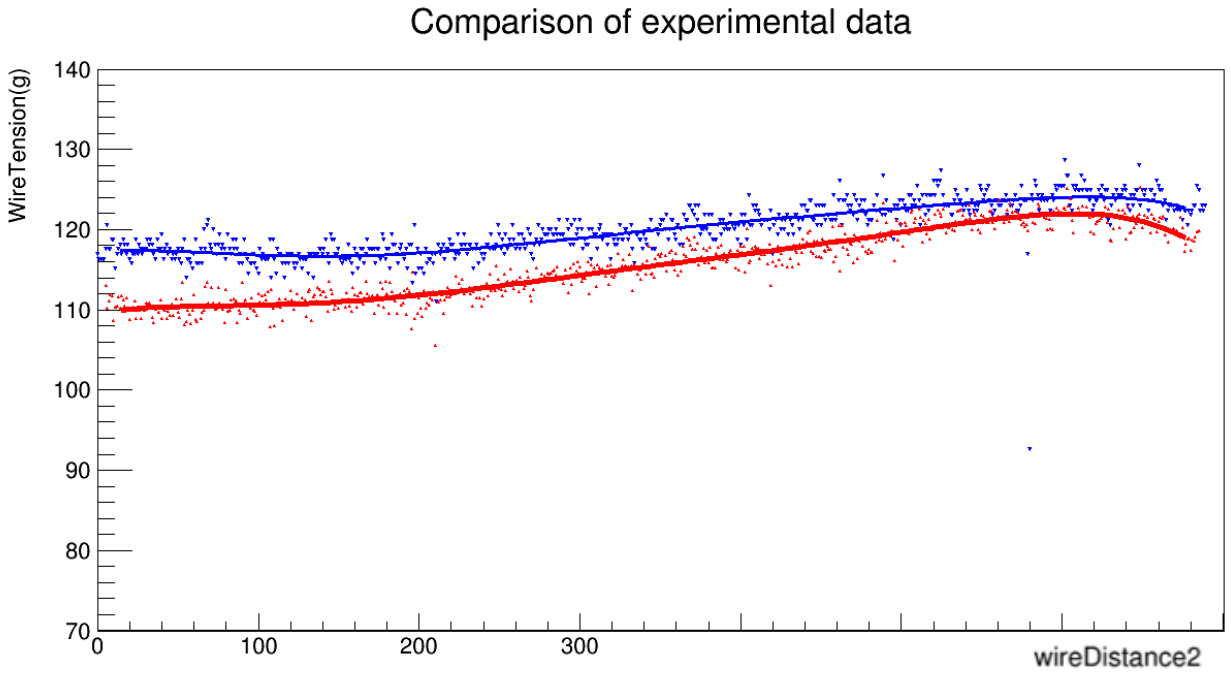
1st practice

10~20g tension reduction, need further investigation

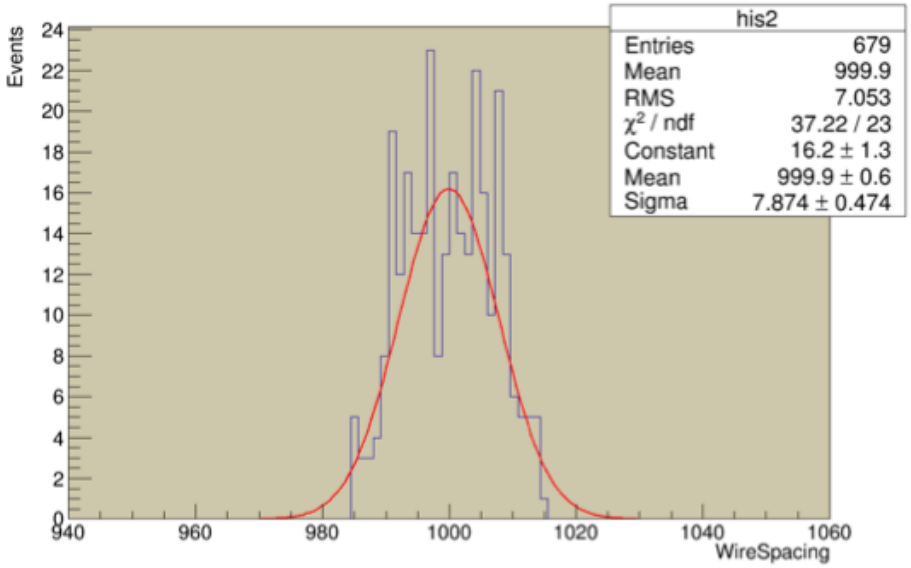


-Assembly Practice

Gated wire tension before & after mounted on sector

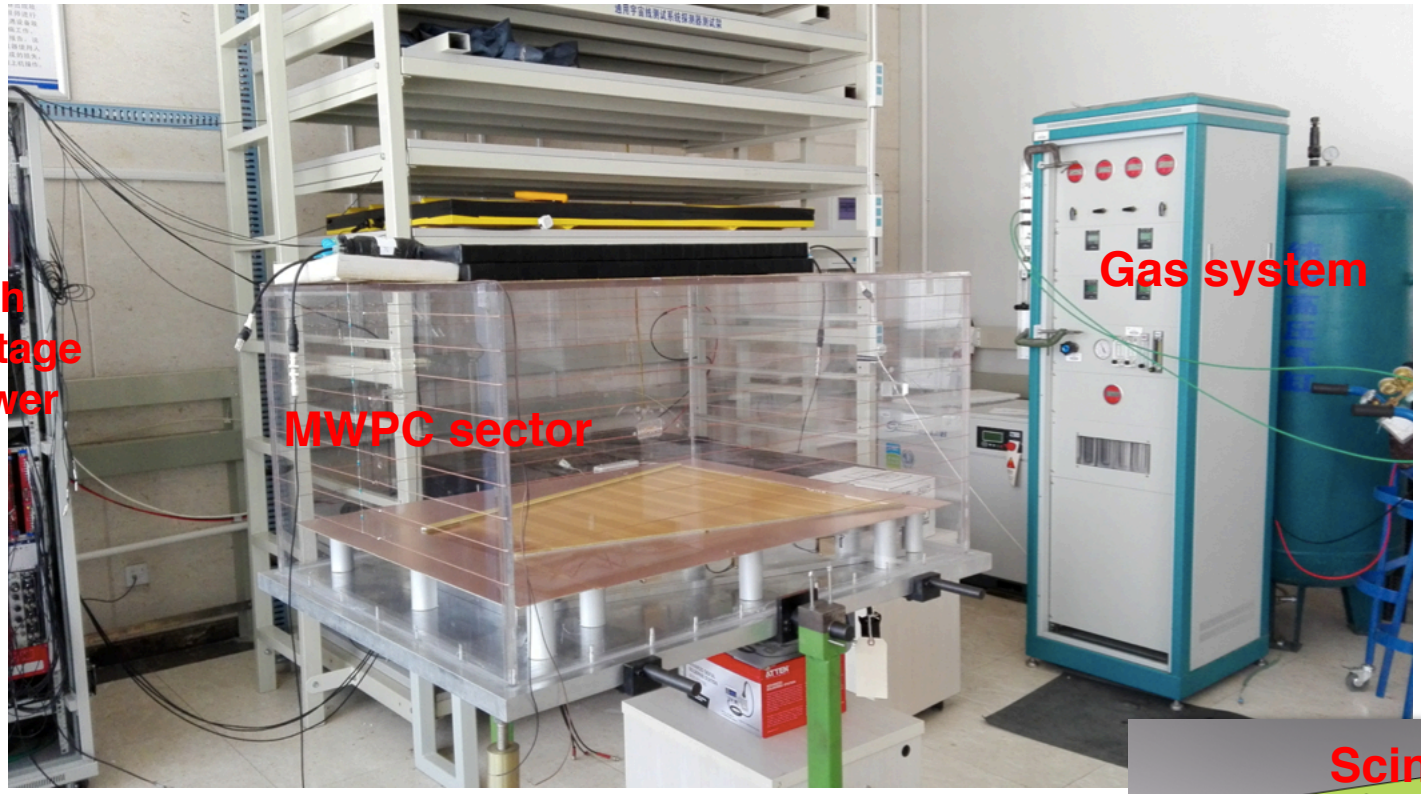


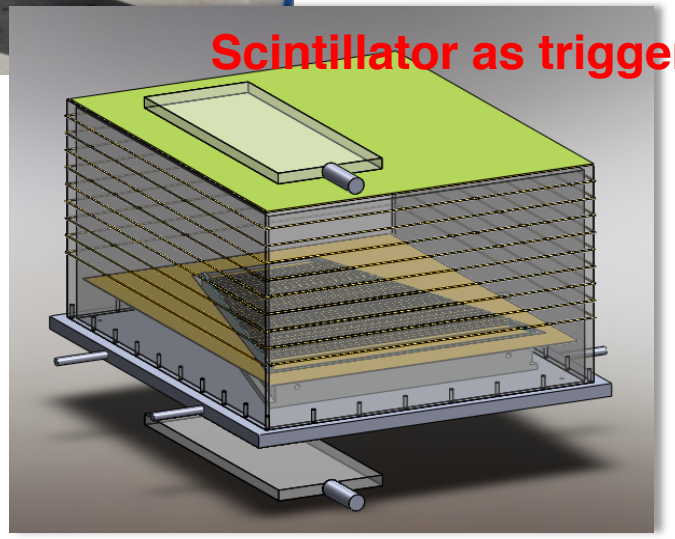
- **Need to further monitor the tension after mounted in further prototyping with final strongback & wire mounts**
- **The wire pitch remains good precision (10um)**



-Assembly Practice

Test system (cosmic ray) with STAR DAQ system



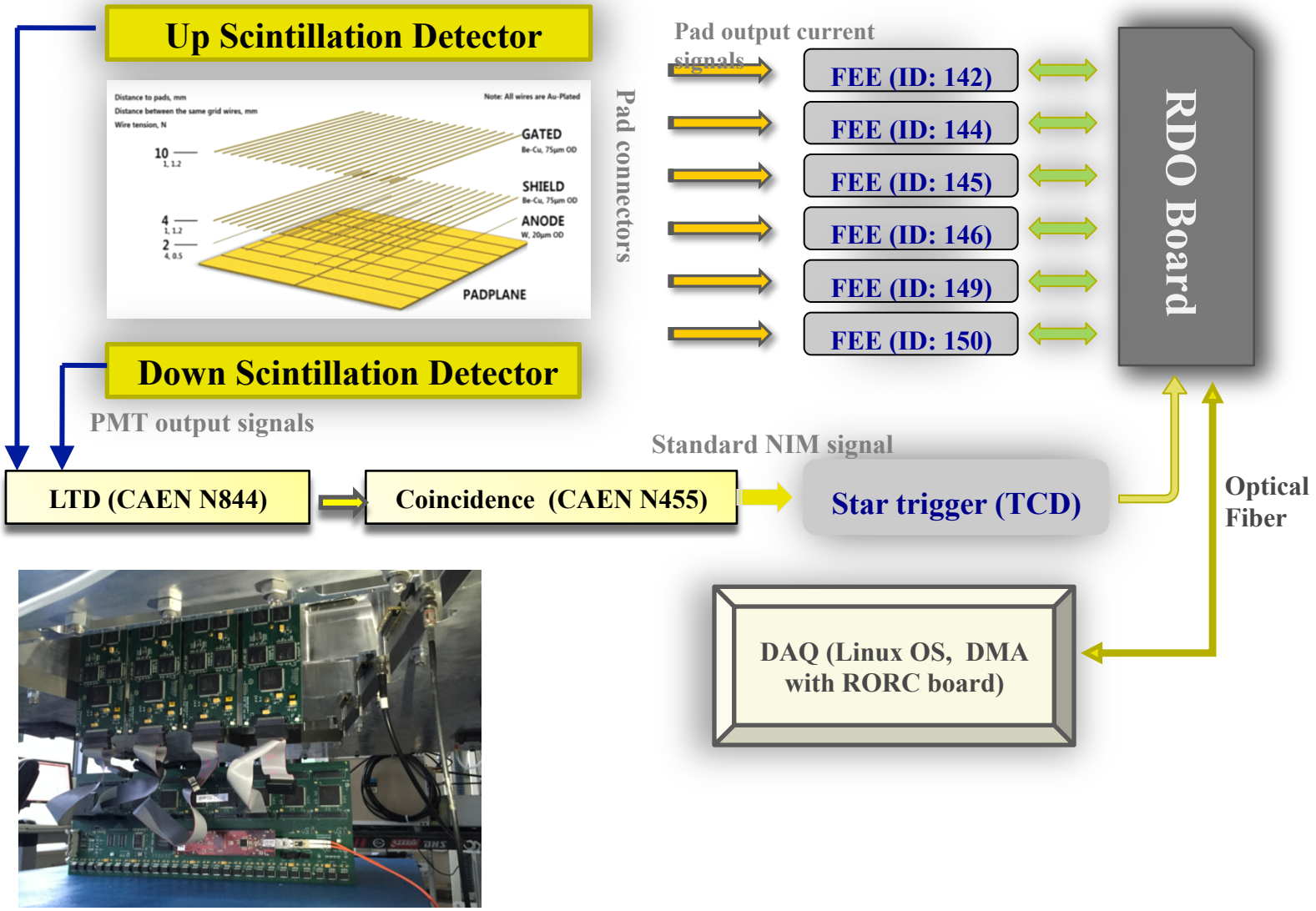


A testing system has been built based on STAR DAQ.

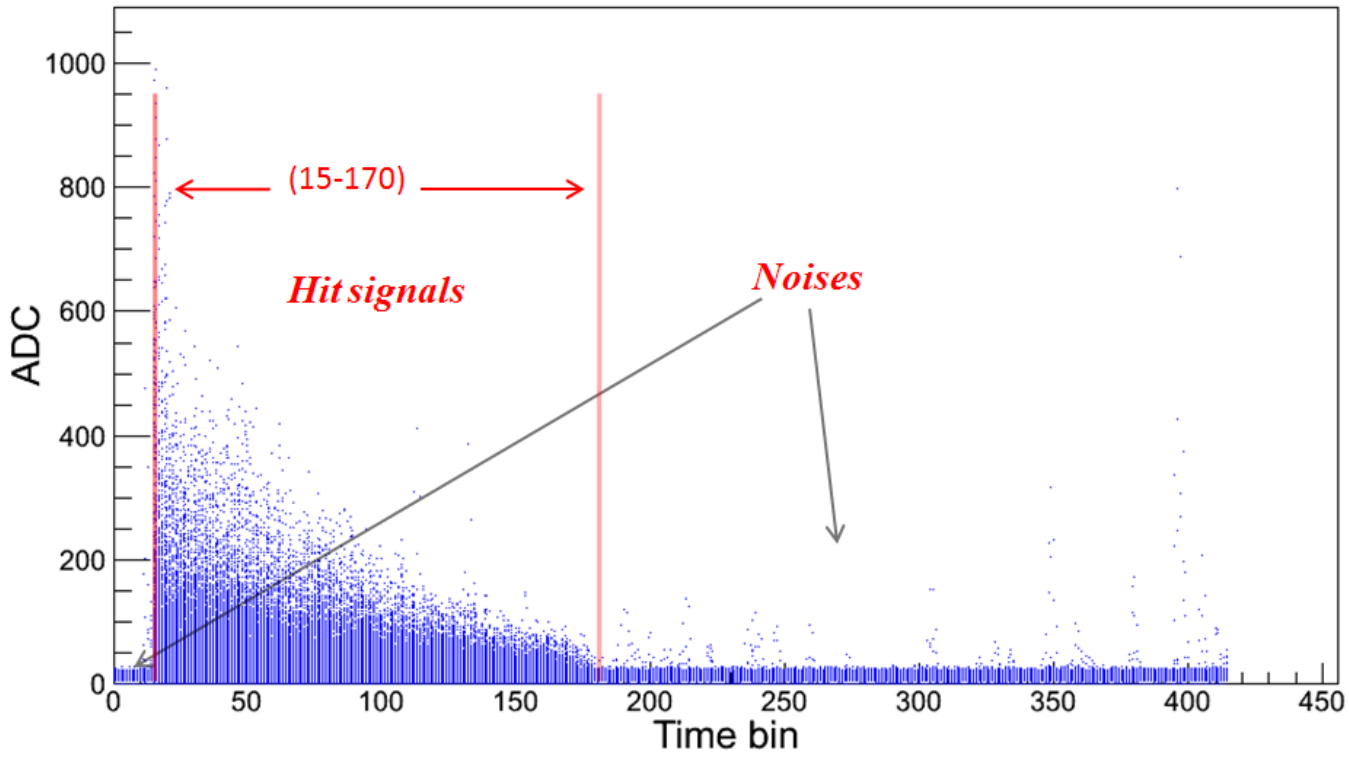
Cosmic ray was first used.

Testing based on 55Fe and X-ray source has been processing for gain scan

The electronics and DAQ system for the iTPC test

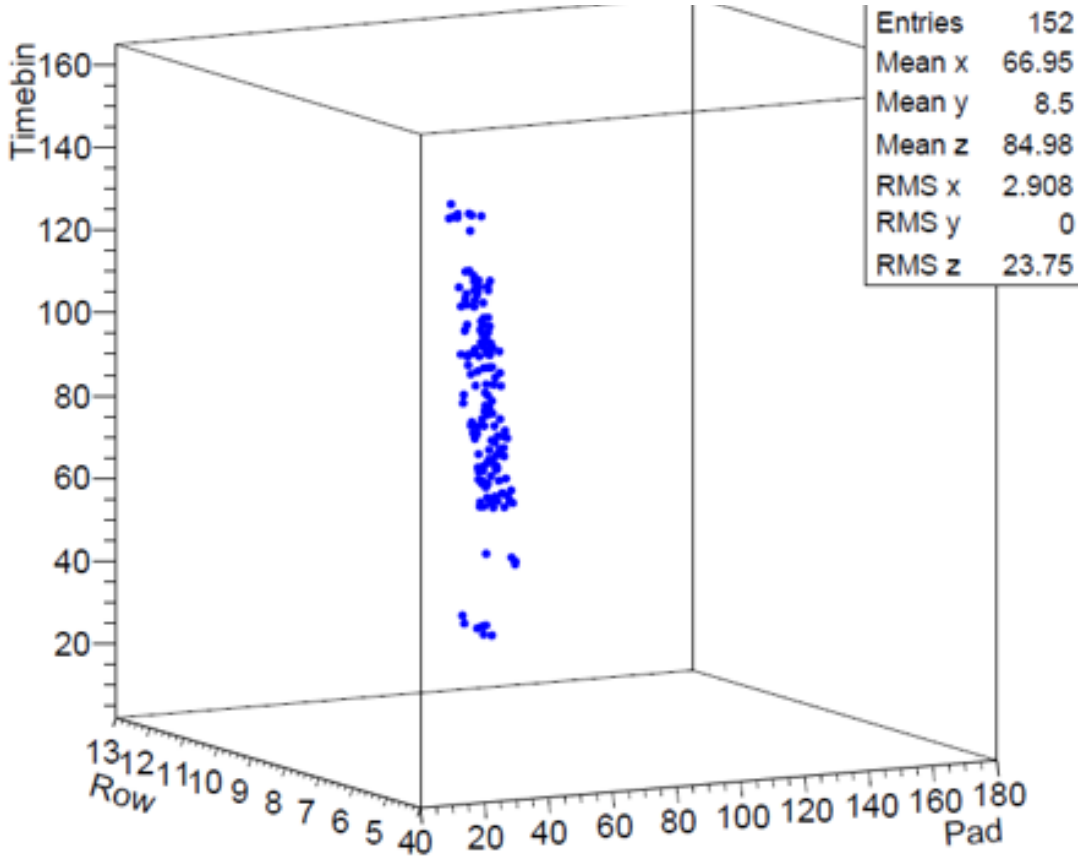


Time bin information



- Signals appear around time bin 15-170 , -> drifting time is ~155 time bins
- All time bin(0-413) with noises even 15-170 but 414-434, and most of ADC < 20
- Time bin 15-170, higher ADC appears in smaller time bins

Hints of a track

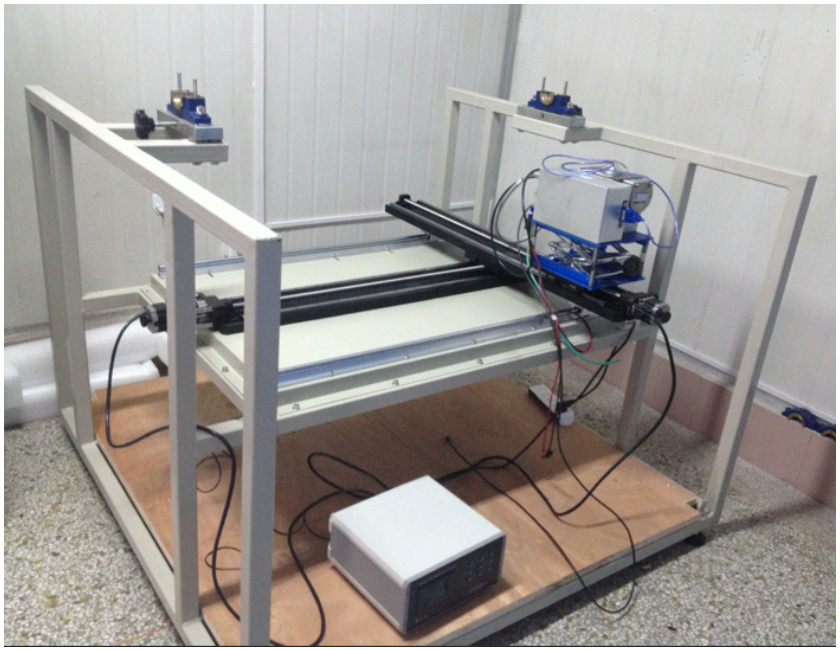


Clustering to find a hit is underway

Testing system for mass production

- 2D movable X-ray system for gain scanning
  - Fe55 and X-ray ready
  - setup to be completed in Sep.

Test chamber: 5cm drifting length



Testing plan for mass production:

- Sector burn-in and leak current
- Quantity to check with HV:
  - ✓ Efficiency (pad response)
  - ✓ Gain uniformity (wire scan using Fe^{55} source)

Time cost per sector for mass production

- **2~3 weeks for detector assembly, 1 week for test**

	items	Time cost (day)
Inspection	Inspection & check	1
Assembly	Anode wire mounting	4
	Shield wire mounting	3
	Gated wire mounting	4
Testing	HV burn-in	1
	Efficiency	2
	Gain & uniformity	2

- One day for inspection & checks for pad plane and side wire mounts

- Above estimate based on modern epoxy Araldite 2011/AB (24h) -> 12 days in total

- Original epoxy (Epon 826+Versamid 140, 40h) will add 3 days ->15 days in total

Production plan & schedule

Sector arrival from LBL

3.6.6	Production	408 days	Tue 3/21/17	Thu 10/25/18	##
3.6.6.1	Assemble with MWPC	90 days	Tue 3/21/17	Mon 7/24/17	##
3.6.6.2	Test	84 days	Mon 4/10/17	Thu 8/3/17	##
3.6.6.3	Ship to BNL	20 days	Fri 8/4/17	Thu 8/31/17	##
3.6.6.4	First 6 modules at BNL	0 days	Thu 8/31/17	Thu 8/31/17	##
3.6.6.5	Assemble with MWPC	90 days	Tue 7/25/17	Mon 11/27/17	##
3.6.6.6	Test	84 days	Mon 8/14/17	Thu 12/7/17	##
3.6.6.7	Ship to BNL	20 days	Fri 12/8/17	Thu 1/18/18	##
3.6.6.8	Nextt 7 modules at BNL	0 days	Thu 1/18/18	Thu 1/18/18	##
3.6.6.9	Assemble with MWPC	90 days	Tue 11/28/17	Mon 4/16/18	##
3.6.6.10	Test	84 days	Mon 12/18/17	Thu 4/26/18	##
3.6.6.11	Ship to BNL	20 days	Fri 4/27/18	Thu 5/24/18	##
3.6.6.12	Next 6 modules at BNL	0 days	Thu 5/24/18	Thu 5/24/18	##
3.6.6.13	Assemble with MWPC	90 days	Tue 4/17/18	Mon 8/20/18	##
3.6.6.14	Test	84 days	Mon 5/7/18	Thu 8/30/18	##
3.6.6.15	Ship to BNL	20 days	Fri 8/31/18	Thu 9/27/18	##
3.6.6.16	Last 7 modules at BNL	0 days	Thu 9/27/18	Thu 9/27/18	##

Last 7 ship to BNL

Production procedure – strictly being followed

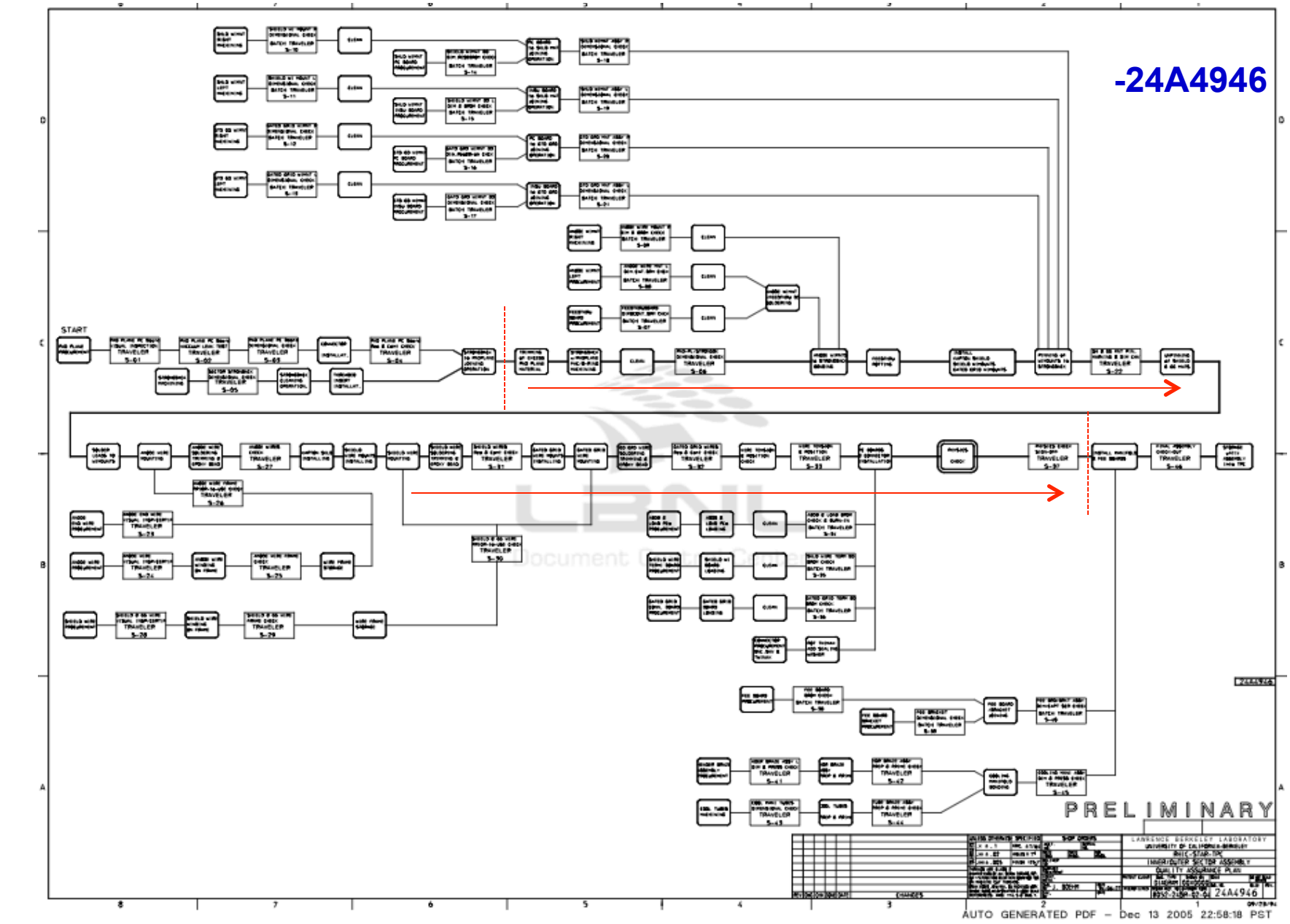
iTPC Production Procedure

iTPC 丝室制作流程

目录

iTPC 丝室制作流程

Original QA plan for assembly- flow chart with travelers



Traveler example:

TRAVELER S-19

NOTE: This is a Batch traveler
注意：这是一个批处理检验文档。

SHIELD WIRE MOUNT ASSY, LEFT, DIMENSIONAL CHECK 左侧地丝落丝配件，尺寸检验

SHIELD WIRE MOUNT ASSY, LEFT, INNER SECTOR, dwg # 24A4564 Amount: _____ each
左侧地丝落丝配件，内扇区，dwg # 24A4564 总计：_____/每个

After answering each of the following questions please initial your name. 完成下列检查后请签名。

VISUAL INSPECTION 外观检验

1. Is there excessive squeezed out epoxy?
   有无被挤压出的过多的环氧树脂胶？ **Yes**___, **No**___
2. Are there epoxy drips on the shield wire mount?
   有无胶滴落到地丝落丝件上？ **Yes**___, **No**___
3. Is there any epoxy on the top of the insulation board??
   有无环氧树脂胶在绝缘板上面？ **Yes**___, **No**___

IF THE ANSWER TO ANY QUESTION ABOVE IS **YES** BAG AND TAG ASSEMBLIES with **"REJECTED-VISUAL"**
AND
NOTIFY COGNIZANT ENGINEER
如果任何上述问题的答案是 **YES** 收起配件并打上 **"驳回-外观"** 的标签，同时通知相关的工程师。

DIMENSIONAL INSPECTION 尺寸检验

4. MEASURE all Shield wire mount assemblies
   Do all assemblies conform to their Dimensions and Tolerances shown on the appropriate drawing?
   SHIELD WIRE MOUNT ASSY, LEFT, INNER SECTOR, dwg # 24A4564
   测量所有地丝落丝件
   是否所有地丝落丝件的的尺寸和公差都符合相关图纸中所示？
   左侧地丝落丝配件，内扇区，dwg # 24A4564 **Yes**___, **No**___

Tag any Assembly that is out of Spec with "**REJECTED-DIMENSIONS**"
把任何不合要求的配件标注 "**驳回-尺寸**"

INSTRUCTIONS 说明

If item 4 is marked **NO**, tag the assembly **"REJECTED"** and mark below and place it in "reject storage". If item 8 is marked
YES, attach this inspection record and place the assembly in "to-be-cleaned storage".
如果问题 4 答案是 **NO**，把配件标注 "**驳回**"，在下面标注并把它
放入 "驳回储存区"。如果问题 4 答案是 **YES**，附上此检验记录并把配件放入 "待清洁" 储存区。

Engineer's signature 工程师签名_____ Inspection date 检验日期：___/___/201___

Inspector's signature 检验员签名_____ Inspection date 检验日期：___/___/201___

PASS 通过_____ **REJECTED 驳回**_____

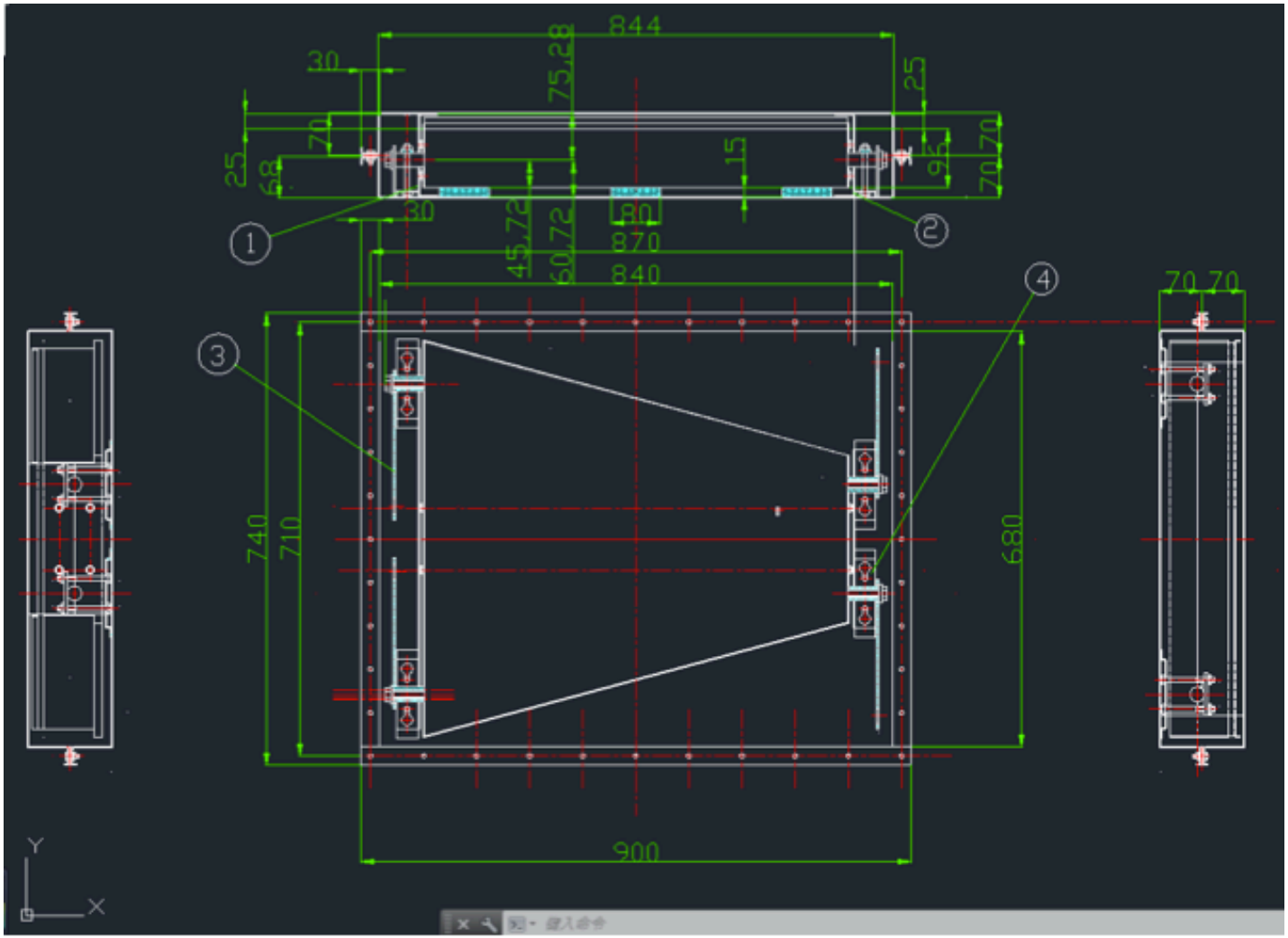
Risks and mitigation

- Dust/fiber on wire plane, which may lead to spark for the sector
  -> build clean room for both wire winding and tension measurement

- Broken wire or sector damage during shipping from China to BNL
  -> build shipping box with safe design, make tests before shipping

- Broken wire during detector assembly
  -> replace the wire if possible, if not, then remove all the wire plane and redo the wire mounting

Shipping box design underway



Summary

- Funding secured for prototyping and production of MWPC.
- Related tools & fixtures for production designed. QA procedure is designed.
- The 1st pre-prototype finished. The setup of test/DAQ system is underway for cosmic ray & Fe55, X-ray.
- There was 1st internal review for MWPC on Aug. 3; collaboration review planed in ~late October.
- The mass production will be ready in Jan 2017.

Notice of MoST funding : 2013.10

科学技术部文件

国科发基〔2013〕627 号

科技部关于国家重点基础研究发展计划 2014 年项目立项的通知

天津市、辽宁省、吉林省、上海市、江苏省、浙江省、山东省、湖北省、湖南省、重庆市、四川省、云南省、陕西省、新疆自治区、宁波市、厦门市科技厅（委、局），深圳市科技创新委，教育部、工业和信息化部、国土资源部、农业部、卫生计生委、中科院、气象局、中医药局办公厅（室），总后勤部卫生部、总装备部司令部，各有关单位：

国家重点基础研究发展计划（以下简称 973 计划，含重大科学研究计划）2014 年项目申报评审工作已经结束。为贯彻落实《国家“十二五”科学和技术发展规划》，加强面向国家战略需求的基础研究，经研究，决定批准 973 计划农业科学等 9 个领域 91 个项目、蛋白质研究等 6 个重大科学研究计划 40 个项目以及青年科学家专题 32 个项目立项（项目清单见附件）。

根据 973 计划工作安排，这批项目将于 2014 年启动实施。请各有关单位按照 973 计划管理办法和经费管理办法的要求，认真做好项目组织实施的相关工作。

特此通知。

附件：国家重点基础研究发展计划 2014 年项目清单

中华人民共和国科学技术部 科技部

2013 年 10 月 21 日

（此件主动公开）

1

2014CB745200	合成生物器件干预肺脓癌的基础研究	深圳市科技创新委员会	深圳大学	慕志明
2014CB845300	不确定信息下多体导航与控制的系统理论和数学基础	中国科学院	中国科学院数学与系统科学研究院	孙振东
2014CB845400	高温高密核物质形态研究	中国科学院、上海市科学技术委员会	中国科学院上海应用物理研究所	马余刚
2014CB845500	强流高功率离子加速器物理及技术先导研究	中国科学院	中国科学院近代物理研究所	赵红卫
2014CB845600	团簇多级结构的构筑与功能调控	教育部、厦门市科学技术局	厦门大学	谢素原
2014CB845700	基于 LAMOST 大科学装置的银河系研究及多波段天体证认	教育部	北京大学	刘晓为
2014CB845800	伽马射线暴与相关前沿物理研究	教育部	南京大学	戴子高
2014CB845900	核幔耦合作用与亚年代至世纪尺度地球自转及磁场变化关系研究	中国科学院	中国科学院测量与地球物理研究所	倪四道

Notice letter of NSFC funding : 2015.8

关于国家自然科学基金资助项目批准及有关事项的通知

徐庆华　先生/女士：

根据《国家自然科学基金条例》的规定和专家评审意见，国家自然科学基金委员会（以下简称自然科学基金委）决定批准资助您的申请项目。项目批准号：11520101004，项目名称：RHIC/STAR时间投影室的升级和能量扫描二期的实验研究，直接费用：290.00万元，项目起止年月：2016年01月至2020年12月，有关项目的评审意见及修改意见附后。

请尽早登录科学基金网络信息系统（https://isisn.nsfc.gov.cn），获取《国家自然科学基金资助项目计划书》（以下简称计划书）并按要求填写。对于有修改意见的项目，请按修改意见及时调整计划书相关内容；如对修改意见有异议，须在计划书电子版报送截止日期前提出。**注意：请严格按照《国家自然科学基金资助项目资金管理办法》填写计划书的资金预算表，其中，劳务费、专家咨询费科目所列金额与申请书相比不得调增。**

计划书电子版通过科学基金网络信息系统（https://isisn.nsfc.gov.cn）上传，由依托单位审核后提交至自然科学基金委进行审核。审核未通过者，返回修改后再行提交；审核通过者，打印为计划书纸质版（一式两份，双面打印），由依托单位审核并加盖单位公章后报送至自然科学基金委项目材料接收工作组。计划书电子版和纸质版内容应当保证一致。

向自然科学基金委提交和报送计划书截止时间节点如下：

1、提交计划书电子版截止时间为**2015年9月11日16点**（视为计划书正式提交时间）；

2、提交计划书电子修改版截止时间为**2015年9月18日16点**；

3、报送计划书纸质版截止时间为**2015年9月25日16点**。

请按照以上规定及时提交计划书电子版，并报送计划书纸质版，未说明理由且逾期不报计划书者，视为自动放弃接受资助。

附件：项目评审意见及修改意见

国家自然科学基金委员会
数理科学部
2015年8月17日

Agreement on Joint Research on iTPC

山东大学 SHANDONG UNIVERSITY

Agreement on Joint Research on

RHIC/STAR-TPC detector upgrade and the experimental study on Beam Energy Scan II

between

Shandong University & the STAR Collaboration

I. Collaborative Research Title

RHIC/STAR-TPC detector upgrade and the experimental study on Beam Energy Scan II

II. Leading Scientists

Party A:

Principal Investigator: Prof. Dr. Qinghua Xu

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Tel.: 86 531 88364515

Fax: 86 531 88364456

Address: 27 Shanda South Road, Jin'an, Shandong 250100

Main Participants (Participating Universities/Institutes and other Institutions):

Prof. Liang Xue, Shandong University (SDU)

Dr. Jian Deng, SDU

Mr. Yansheng Sun, SDU

Mr. Peng Lu, SDU

Mr. Hui Zeng, University of Science and Technology of China (USTC)

Dr. Chi Yang, USTC

Mr. Qian Yang, USTC

Prof. Dr. Jinhui Chen, Shanghai Institute of Applied Physics, CAS (SINAP)

Dr. Longxiang Long, SINAP

Party B:

Principal Investigator: Dr. Flemming Videbaek

E-mail: videbaek@bnl.gov

Tel.: +1 631 344-4106

Fax: +1 631 344-4206

Address: Brookhaven National Laboratory (BNL), Upt

Main Participants (Participating Universities/Institutes

Dr. James Thomas (Lawrence Berkeley National Labor

Dr. Tonko Ljubicic (BNL)

Prof. Jerry Hoffmann (University of Texas at Austin)

Dr. Zhangbu Xu (BNL)

III. Research Plan, Division of Labor and Timet

The project aims to study the property of QGP and to transition in the phase digram. We propose to achieve inner sectors of Time Projection Chamber (iTPC) at S Beam Energy Scan phase II (BES-II) at RHIC. The I collisions at different energies. The improved accep iTPC upgrade at STAR, resulting in an increase in 70-80%, will provide several significant improvement proposed quantities (including elliptic flow, multiplicit to search for the critical point.

The project will strengthen the collaboration between USTC and SINAP) and the STAR experiment at Laboratory, and both parties will benefit significant succeeds. The plan for both sides is to work on t transition in relativistic nuclear collisions, which incl the iTPC detector upgrade and the data analysis for the

The project consists of detector upgrades and physic

Without the written consent of both parties, none of the project's common IPR may be transferred to any third-party.

VI. Duration, Amendment and Withdrawal

The project will terminate upon completion of all research activities, which is agreed on the date of March 5, 2015. A research partner who decides to withdraw from the project before the above-mentioned date should notice other members of the collaborative research at least three months before the change happens. Any amendments to this agreement should be agreed by both parties.

VII. Legal Validity

This agreement comes into effect on Jan 1, 2016 and terminates on Dec 31, 2020. It is made in two counterpart originals and two counterpart copies, with one of the originals to be retained by each of the two parties and one of the copies to be retained by NSFC and Shandong University respectively.

VIII.

Signature:

Party A: Qinghua Xu (PI)

Time: March 6, 2015

Place: Jinan, China

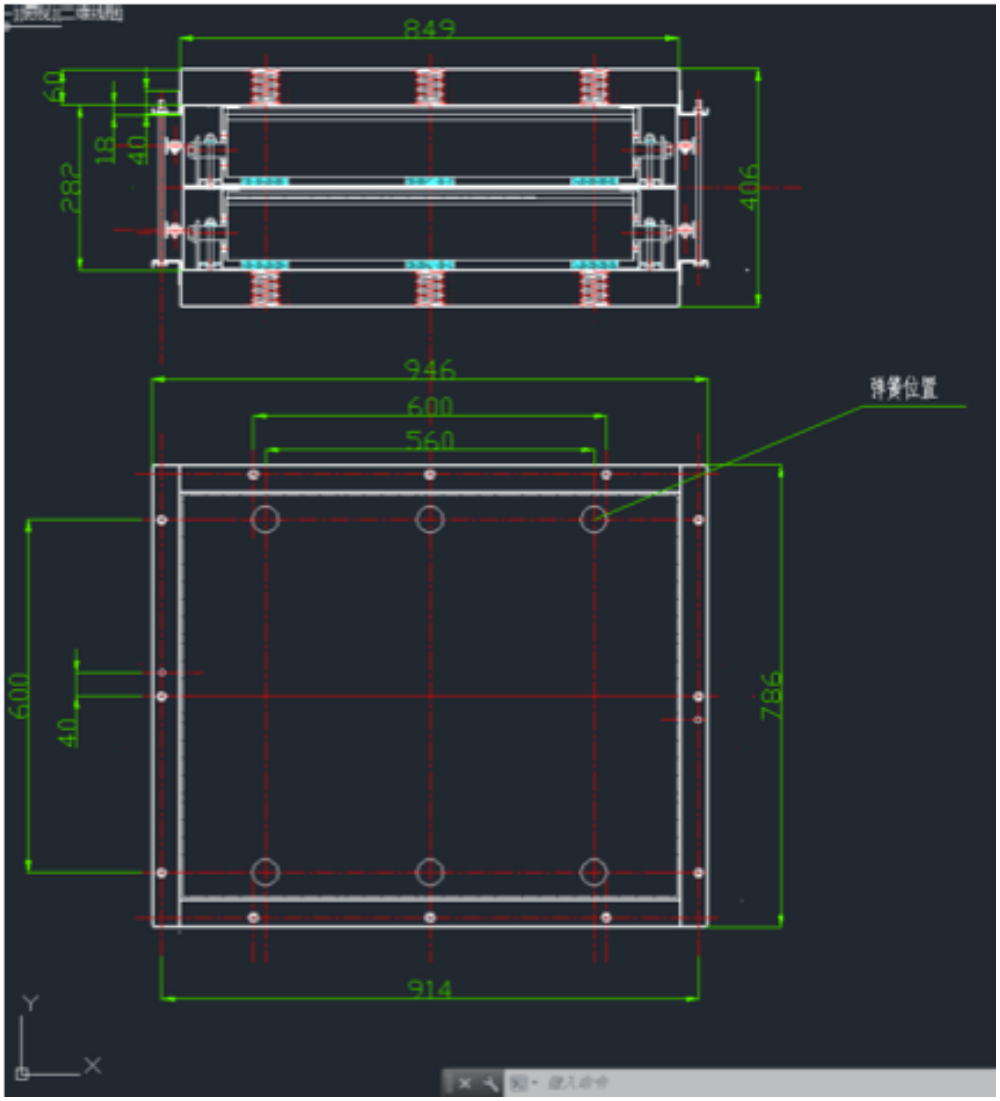
Party B: Flemming Videbaek (Co-PI, iTPC manager)

Zhangbu Xu (STAR Spokesperson)

Time: March 6, 2015

Place: Jinan, China

Shipping box



MWPC production 探测器制作流程